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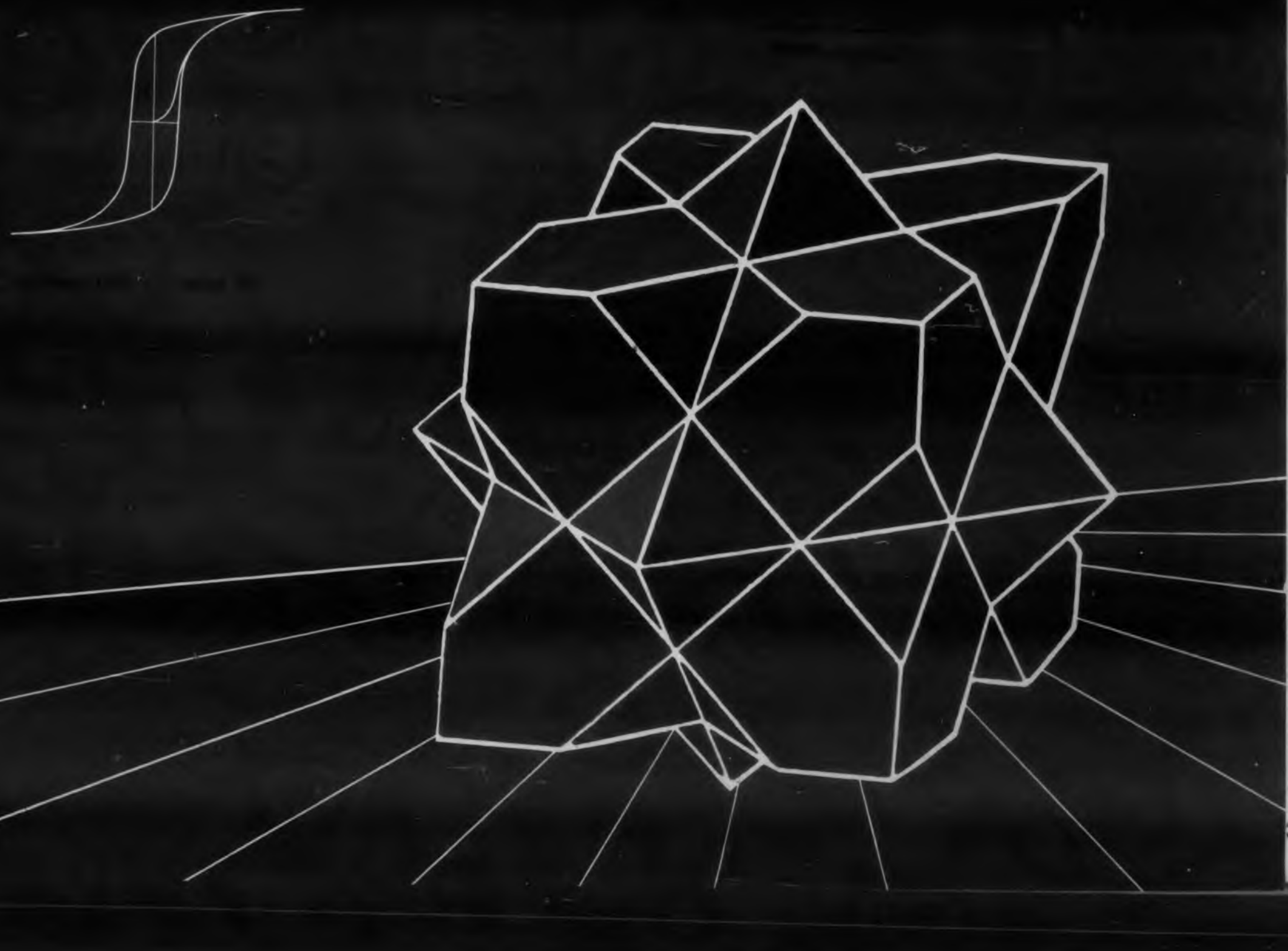

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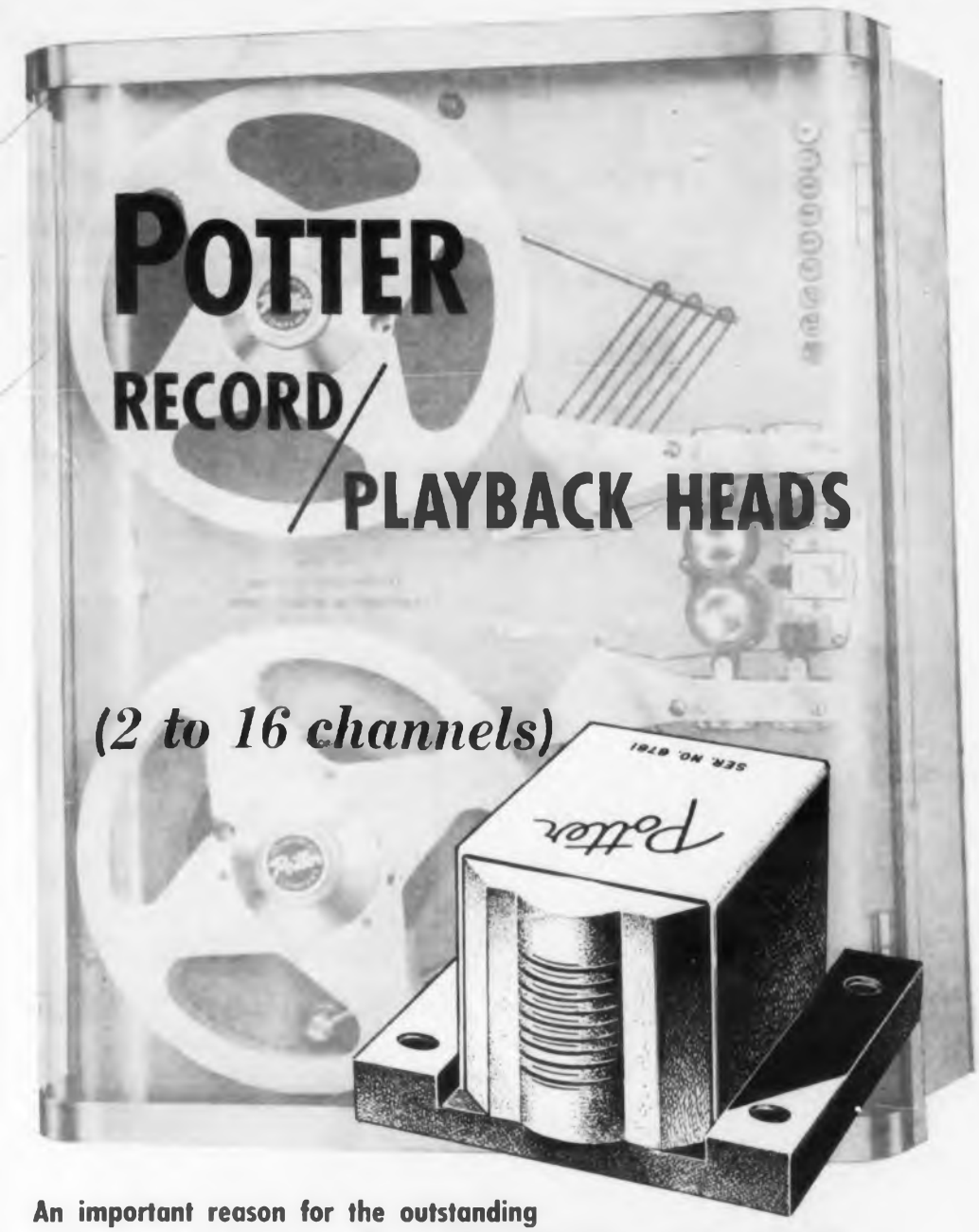

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Precision designed to meet highest standards of performance and reliability... *machined bronze... solidly constructed to close tolerances... high dimensional stability... full shielding between channels... precisely aligned gaps.*

Track width:	.020″ to .031″ ± .001″
Track spacing:	.078″ to .050″ ± .001″
Gap width:	.0005″
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Record Current:	10 mhy: 10 ma. 1 mhy: 30 ma. Rise time: 1 μ sec
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CIRCLE 2 ON READER-SERVICE CARD FOR MORE INFORMATION

Editorial

Reliability for the Engineer

Information on reliability techniques has generally taken one of two unsatisfactory forms. Some articles say "We need better reliability," and quote "the basic" probability equation, $P = p_1 \cdot p_2 \cdots p_n$; others are so sophisticated and so obscure as to be unintelligible to the design engineer who has little formal training in statistical analysis.

That there is a need for greater reliability in military and commercial equipment is axiomatic; that the one person most concerned with techniques for producing a reliable piece of equipment is the engineer designing the system or unit is clear beyond question.

And yet there is a surprising dearth of reliability information specifically directed at the design engineer. Normally he does not have the background necessary to apply advanced variance-analysis methods toward the solution of his problem. At the same time he needs to know more than "We need better reliability." The half-way-between approach has been conspicuously lacking.

Two principal restrictions handicap the engineer. He very often doesn't have enough time to design his equipment, much less run elaborate reliability tests on all the components and circuit parameters making up his system. Moveover the cost of a long run of precise, statistically-significant tests is too high. A good quality-control system can help appreciably here, both at the output end of the component manufacturer and at the input end of the equipment assembler's plant. But what is urgently needed is a clear picture of just what circuit designs are preferable, reliability-wise, what environmental isolation is required, information on part deratings and safety margins, redundancy, and preventive maintenance and replacement considerations.

One proposed solution to the problem is to set up a reliability department, consisting of "reliability engineers." These engineers would review design drawings and evaluate the reliability of the proposed system, as well as—presumably—run component tests. The reliability department would make recommendations and inform the design department of the estimated numerical reliability of the system.

The trouble is that there is still an engineer shortage. This means that reliability personnel are not readily available; that consequently the design engineer must learn reliability analysis and prediction techniques for himself; and that for some time he will be doing double duty. Reliability information—sound, high-level information of immediate practical use to the design engineer—is rapidly becoming essential. T.M.

Engineering Review

For more information on developments described in "Engineering Review," write directly to the address given in the individual item.

The black spaces between the sweeps of this TV display have been practically eliminated by applying a vertical deflection of 15 mc to the sweep.

Split-Grid TV

The dark horizontal lines clearly visible between the successive traces of a television display have nearly been eliminated. Reduction of the scanning lines is made possible by a simple change in the construction of the cathode ray tube, basically consisting in splitting in half the tube's focusing grid. The technique was invented by Dr. E. Atti and J. A. Hall of Westinghouse's electronic tube division, Elmira, N.Y.

The split focusing grid still serves its regular function of concentrating the electron beam on the screen, but at the same time a fluctuating voltage is applied which wobbles the beam up and down at about 15 mc. This wobbling voltage is supplied by a single tube at the base of the CRT. Fluctuation of the sweep is enough to fill in the blank area between the sweeps without blurring the image.

Previous experiments had shown that a viewer moves back from a television picture until he just fails to clearly distinguish the individual horizontal lines. For a 24-inch picture, this normal viewing distance turns out to be about 10-1/2 feet. Placed closer than this the viewer begins to distinguish the horizontal line structure of the picture, which structure he finds distracting. With the line structure reduced or eliminated, television pictures larger than those furnished by the usual 17- or 21-inch receiver can be viewed with comfort at short distances.

With the split-grid modification, the viewer will have to become accustomed to a picture which is without lines. Although there is no loss of detail or resolution in the picture, most viewers tend to associate the presence of lines with good focus. Once accustomed to it, however, the average viewer is expected to prefer larger television pictures which offer low line structure.

Heart Microphone: To make possible accurate examination of the human heart, a piezoelectric ceramic element has been enclosed within a tiny catheter. In use, an opening is made in a vein or artery and the catheter tip is inserted and pushed through the blood vessel until the microphone reaches the desired location in the heart. Heart sounds can be recorded accurately from different locations within the heart, and there are none of the usual distortions generated by body tissue lying between the heart and the outside or by the patient's breathing. The microphone is comprised of a diaphragm, pointer and a piezoelectric ceramic element. The ceramic element consists of two thin outer layers of piezoelectric ceramic and a thin inner layer of metal.

Accurate Radar Mapping

Photographs of radar displays are not normally true maps since they contain many distortions and inaccuracies. The chief distortion is caused by the fact that radar records the slant distance between an airborne radar set and a ground object, whereas it is the ground distance between the aircraft's nadir and the ground object which is needed. Thus an object directly under a plane will appear a certain distance (equal to the plane's altitude) from the beginning of the radar sweep. A sweep delay initiated to compensate for this "altitude hole" in the middle of the scope will only cause error in measuring the distance of more distant objects. Still another error is caused by the plane's motion during one scan of the radar. Although this error can be minimized by a fast scanning rate, there will still be an appreciable error with fast-flying airplanes.

For the solution of these problems, a corrective device called a Radar Restitutor has been designed by the Electronics Division of Fairchild Controls Corp., a subsidiary of Fairchild Camera and Instrument Corp. The correction for the error due to slant vs ground distance is brought about through optics. A curved-mirror solution was first proposed, but

Called the Radar Restitutor, this device enables the accurate mapping of ground objects from an airborne radar set. The problems inherent in radar mapping, such as the necessity to convert slant to ground range and the need to compensate for the plane's motion, are accurately solved. The principle employed is essentially that of a rotating optical system.

found unsuccessful due to the mathematical analysis which revealed no simple way of generating the needed curve. The slant to ground range correction was finally solved by the use of a rotating optical system consisting of three lenses and two mirrors. The uncorrected photograph is so centered in the system that the error due to sweep delay compensation for the "altitude hole" is also corrected.

The other major distortion, that due to the plane's motion, was solved by moving the film at a speed and direction proportional to the plane's travel. The resulting complete system was tested and found to have an accuracy of four parts per thousand and to qualify well for field use by unskilled operators.

Medical Instrumentation Clinic

Despite the variety of developments in instrumentation spawned by industrial and military demands, relatively little of this development has benefited the medical profession. A semantic as well as technical curtain has thwarted cross-fertilization, and specialists in both instrumentation and medicine have lacked the time and motivation to penetrate this curtain. Few physicians have the technical knowledge needed to develop new instruments. Conversely, most professional instrument designers have little background in biological fundamentals.

An experiment in technical cross-fertilization may offer a way to crack this barrier between the fields. Called a Conceptual Clinic by its cosponsors (the Foundation for Instrumentation Education and Research, and the New England Institute for Medical Research) the experiment will bring together two dozen of the country's top professional instrument designers and a group of highly qualified biological-medical researchers. Cloistered for two days at the Institute's laboratory in Ridgefield, Conn., the scientists, doctors, and engineers will explore the potential of new instrument techniques for measuring and diagnosing physical and chemical variables in the human being.

Instrument men will first be exposed to an intense briefing—with demonstrations—on some of the measuring problems in medical diagnosis and biology. A few specific diseases will also be covered. A significant feature of this briefing is that the medical men will be primed to use physical and engineering terms that easily fit the lexicon of the instrument man. The meeting will then be reversed and the instrument professionals will hold the floor. Their suggestions for new ways to attack measuring problems will be investigated by all members of the clinic. It is expected that the group may suggest the rough outlines for at least two or three basic instrument research investigations. These will be followed up—through grants by the Foundation — t appropriate institutions.

Engineering Review

Healthy Curiosity

Almost all of the countries behind the Iron Curtain showed a lively interest in the British Instruments Electronics and Automation Exhibition held during May in Britain. Definite notice of intended visits came from Warsaw, Prague and Budapest, and the British expected visits from several other Iron Curtain capitals.

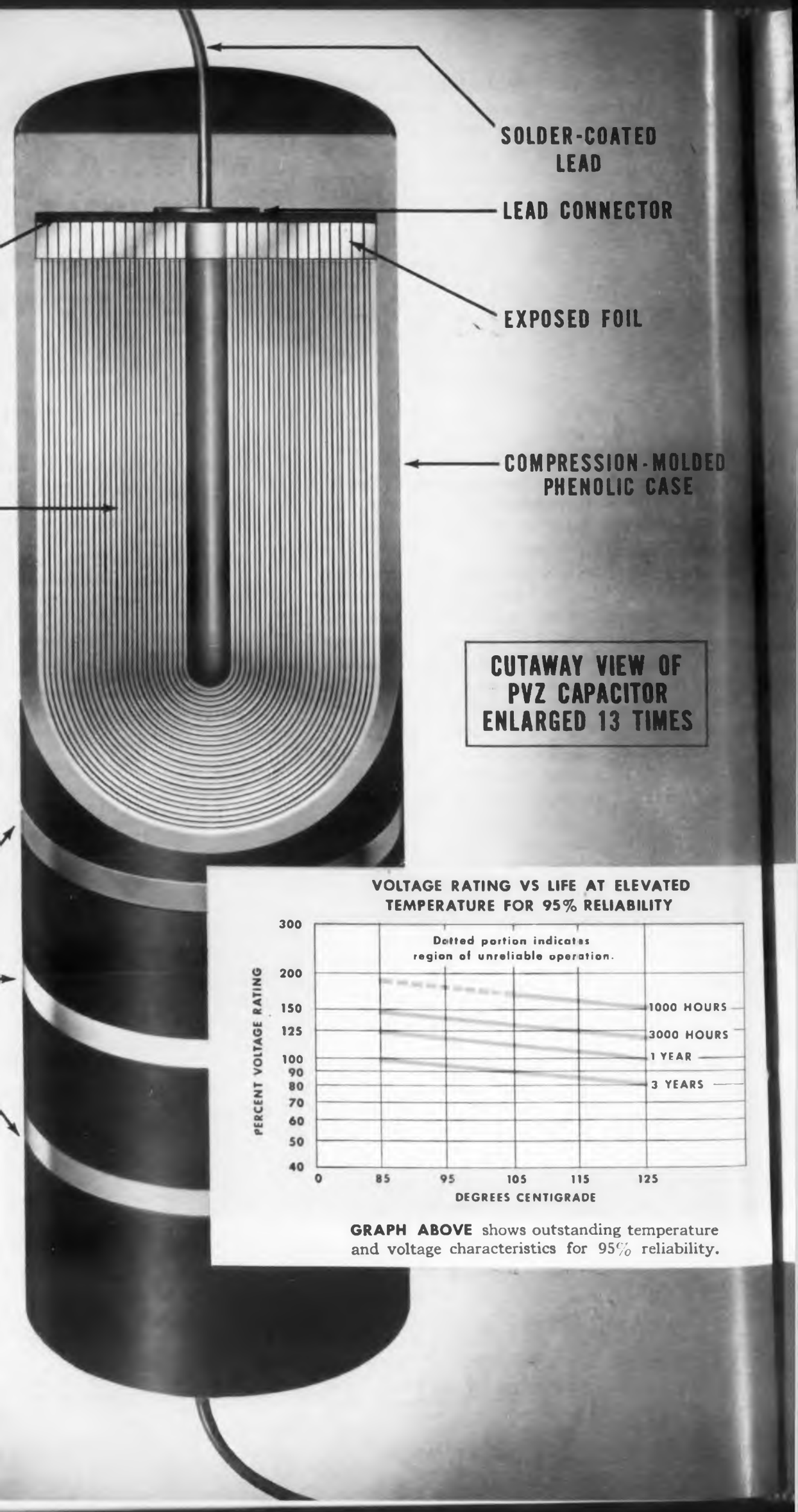
Among the exhibits of the 200 British manufacturers attending, computer lines were prominent. Laboratory instruments, amplifiers, closed-circuit television and communication units were also among the products receiving the most display.

Color TV Test Instrument

Research work in the area of color television techniques has underlined the need for specialist test equipment for use in that field. To this end, a test instrument known as a Vectorscope has been designed to display the chrominance component of the N.T.S.C. type of color television signal. The instrument was developed by Marconi's Wireless Telegraph Co. Ltd., England. The Vectorscope has proved to be of value in the measurement of amplitude and phase relationship in a color signal at any point in a television distribution system. A further application lies in the monitoring of actual color camera signals, since its display gives an objective indication of the hue and saturation of the color components.

The chrominance information is carried on a subcarrier which is modulated in amplitude, representing the color saturation, and in phase, representing the hue. The display is presented on a cathode-ray tube, the radial distance of the spot from the center indicating the amplitude modulation or saturation, while the phase or hue is displayed as the angle subtended from a fixed phase reference on the screen. The use of the Vectorscope in color television is, in fact, analogous to that of a normal oscilloscope employed as a waveform monitor on black-and-white television.

CIRCLE 6 ON READER-SERVICE CARD ➤



CUTAWAY VIEW OF PVZ CAPACITOR ENLARGED 13 TIMES

VOLTAGE RATING VS LIFE AT ELEVATED TEMPERATURE FOR 95% RELIABILITY

GRAPH ABOVE shows outstanding temperature and voltage characteristics for 95% reliability.

Control Council Organized

An organization is being formed to coordinate the activities of the several technical societies involved in control systems engineering. Both international and national in scope, the council proposes the organization and operation of an international federation of control systems engineering, and also the coordination of the professional activities, meetings, conferences, symposia, and joint control meetings of American technical societies.

The proposals were made last March at the Western Society of Engineers in Chicago. Present at the meeting were authorized representatives of the American Society of Mechanical Engineers, the AIEE, the IRE, the Instrument Society of America, and the American Institute of Chemical Engineers.

Outstanding Engineer

The Eta Kappa Nu Association, national electrical engineering honor society, has announced the opening of nominations for 1956's Outstanding Young Electrical Engineer. Nominations are solicited from all accredited colleges, AIEE, IRE and employers of electrical engineers.

Candidates do not have to be members of Eta Kappa Nu, but must be less than 35 years of age and have baccalaureate degrees in electrical engineering from colleges in the U. S. and Canada within ten years prior to May 1, 1957. The award is made on the basis of social and civic accomplishments as well as technical achievements. This is to emphasize among electrical engineers that their service is manifested not only by what they achieve in a purely technical sense, but also in their service to society and their cultural development.

Nomination forms may be obtained from A. B. Zerby, Executive Secretary, Eta Kappa Nu Associations, P.O. Drawer 447, Dillsburg, Pa. Nominations should be returned to Mr. Zerby not later than May 31, 1957; nominations received after that date will be processed, but dossiers may not be complete when the Jury of Award meets in early October.

◀ CIRCLE 6 ON READER-SERVICE CARD

Engineering Review

Microwave Harmonics

The disturbing effects of harmonics in high power microwave systems has become an increasingly important problem with the advent of high power microwave tubes. The problem has been discussed in a paper entitled "Effects and Measurement of Harmonics in High Power Waveguide Systems" prepared by Max F. Ferrer and Kiyo Tomiyasu of the technical staff at the General Electric Microwave Lab. at Stanford University. According to the paper, the harmonic energy generated by high power tubes has reached a level that can no longer be tolerated. The paper went on to give a full description of a new technique for measuring this harmonic energy, which is the first step in the development of suppression filters to prevent these harmonics from being radiated.

The following adverse effects of spurious radiation were stressed: interference to nearby electronic systems; peculiar antenna patterns and false echoes in radar equipment; burn out or blocking of radar receivers; low breakdown power level in waveguides, and errors in measuring power output of microwave equipment.

Taped Blueprints Control Machine: From this console one man can monitor the operation of a tape-controlled 50-ton milling machine. The punched-tape control system was demonstrated recently in Detroit by the Research division of Bendix Aviation Corp. and the Martin Co. It will be used to produce the Martin Matador and the Seamaster four-jet seaplane. Blueprint information is coded on tape and then used to directly control a milling machine for turning out large precision-built structural parts. Control tapes for the system can be produced within hours and then shipped simultaneously to different plants equipped with similar machines.

Direct Reading Spectrum Analyzer

for

- Visual frequency calibration — high resolution
- Leakage and interference measurements
- Standing wave measurements
- Pulse modulation analysis
- Sensitive receiver

e BASIC SCOPE for VISUAL MICROWAVE A

SPECIFICATIONS

Model No.	Equipment
Model Du.....	Spectrum Display and Power Unit
Model STU-1...	RF Tuning Unit 10-1,000 mc.
Model STU-2A.	RF Tuning Unit 910-4, 560 mc.
Model STU-3A.	RF Tuning Unit 4,370-22,000 mc.
Model STU-4...	RF Tuning Unit 21,000-33,000 mc.
Model STU-5...	RF Tuning Unit 33,000-44,000 mc.

Frequency Range: 10 mc to 44,000 mc.
Frequency Accuracy: ±1%
Resolution: 25 kc.
Frequency Dispersion: Electronically controlled, continually adjustable from 400 kc to 25 mc per one screen diameter (horizontal expansion to 20 kc per inch)

Input Impedance: 50 ohms—nominal
Overall Gain: 120 db
Input Power: 400 Watts
Sensitivity: (minimum discernible signal)

STU-1:	10-400 mcs	—85 to —95 dbm
	350-1,000 mcs	—80 to —90 dbm
STU-2A:	910-2,200 mcs	—85 to —95 dbm
	1,980-4,560 mcs	—75 to —87 dbm
STU-3A:	4,370-11,000 mcs	—77 to —90 dbm
	8,900-22,000 mcs	—65 to —85 dbm
STU-4:	21,000-33,000 mcs	—57 to —75 dbm
STU-5:	33,000-44,000 mcs	—50 to —65 dbm

RF internal 100 db continuously variable (STU-1, STU-2A, STU-3A)
IF 60 db continuously variable

Frequency differences as small as 40 kc measurable by means of variable frequency marker with adjustable amplitude. Portable and completely self-contained.

CIRCLE 7 ON READER-SERVICE CARD FOR MORE INFORMATION

Round-the-World Transmission

A short-wave transistor that can reach any spot on earth has been developed for Pentagon use. Primarily for sending vital defense information, the transmitter is nearly 50 times more effective than the loudest commercial broadcasting station.

Called the World Spanner, the transmitter was designed for use as part of the Army's world-wide communication network by the U.S. Army Signal Engineering Labs. at Fort Monmouth, N.J., and by Continental Electronics, Inc., of Dallas, Tex. The power of the set is due to its single sideband design. By filtering out the carrier wave and one sideband, eight times more power is available for the remaining sideband. With ordinary design the World Spanner would have a power of 300,000 w, but with single sideband refinements and a new beam antenna now under development, effective power will reach 24 million w.

Compact design enables the transmitter with all accessories to be housed in a 50-ft square room. Maintenance is apparently not complicated despite this compactness. A 150-lb tube used in its design can be replaced with little more trouble than an ordinary radio tube takes. Although changing channels on a high-power station is usually a major job, the World Spanner allows an operator to go on the air at any one of ten previously set frequencies by turning a switch. 64 teletypewriter messages or 4 separate voices may be transmitted at the same time. Transmission can take place at any frequency in the short wave spectrum from 4 to 30 mc, and a second version of the World Spanner will cover the range from 20 to 65 mc.

One of the tubes used in the new short-wave transmitter is this 150-lb item being lowered into place. The short-wave transmitter is of single sideband design, and is expected to reach any point on earth through all possible types of interference.

Engineering Review

Color X-Rays

The difficulty in reading X-rays due to the lack of contrast will be alleviated by a system employing color TV techniques. Called the Exicon X-ray viewer, the system allows the extraction of the maximum amount of information from an X-ray transparency.

The viewer, developed by Philco Corp., displays X-ray areas of equal optical density in the same color, whereas areas having slightly differential optical density are reproduced in either colors such as blue cyan, green, yellow, orange and red. Thus, opaque solutions injected into the blood system can be followed in color through the heart and blood vessels of the lungs and other organs, lending accuracy and realism to the X-ray picture. Tissues not clearly seen before will be made visible in color. The system consists of monochrome and color monitors, an operators' console and a flying spot scanner. An X-ray negative placed before the flying spot scanner will be magnified and separately reproduced in enhanced monochrome and color. Negatives may be quickly shifted about to obtain magnified images of any portion.

In operation, an amount of light proportional to the transparency of each small area of the negative passes through the negative and is picked up by a photoelectric tube. There the light is transformed into a signal which can be amplified. This signal is then fed to a contrast enhancing device in which adjacent areas of hardly discernible contrast are enhanced well above the threshold of visibility. This signal is fed to a black-and-white monitor and through a color monitor where the X-ray picture is reproduced in color.

Flight Test Data Reduction

The Boeing Airplane Co. at Seattle has done away with a perplexing bottleneck in the flight testing of its new aircraft by using the IBM 701 for reduction of flight test data. Under the new system, the results of a flight test can be appraised within a few hours after the plane has landed, and important data can be deciphered within a few minutes.

Data reduction is an unusual function for the IBM 701, which is more often employed for the solution of single complex problems than the handling of large amounts of data. However, it has proved efficient in this function, and certainly preferable to the old method of manual processing of data. Previously, the Boeing flight test data department often required a crew of 150 persons in what proved to be a slow and costly procedure of data reduction. The IBM 650 was used at a later date, but there was still an appreciable delay in calculations.

he test for which the IBM 701 was programmed consisted of approximately 125,000 data points. These points were to result in 2500 finished plots. The IBM 701 computer was used 12 hours a week for 12 weeks to complete the test. The first week was the only time the plotting could keep up with the calculation. A year previous to this, the IBM 650 was used on a similar test program. Data reduction on this test stretched out over a seven-month period, and plotting had to wait for the computing to be completed. The results of this comparison proved to Boeing that it is practical to use a large scale computer in data reduction.

Correction

On page 34 of the April 1st issue, the constant values k and k′ in the article "Miniature Strip Transmission Line and Components" were incorrectly printed. The correct values are:

$$k = e^{-\pi b/h}$$
$$k' = \sqrt{1-k^2}$$

Weather Station on a Parachute: Called the Dropsonde, this weather-sensing device will be shot out of high-altitude planes in remote or isolated areas, such as polar regions or the eye of a hurricane. Continuously taking temperature, humidity and pressure readings as it falls to earth by parachute from heights up to 11-1/2 mi, the Dropsonde will radio its findings back to the plane. Weighing 10 lbs, the device contains weather sensing units and a miniature transmitter with a possible range of 250 mi. The Dropsonde was developed by General Instrument Corp. of Newark, N.J.

Washington Report

Herbert H. Rosen

FCC and 890 Mc Hearings

The Federal Communications Commission has been hearing for the past two weeks representatives from 14 associations and groups of users of mobile radio. This is the vanguard of some 150 people who responded to the FCC announcement that it was planning to change its rules on the allocation of frequencies of 890 mc and above. Some 45 other groups, who will carry the burden of those remaining, have yet to be heard. The issue at hand breaks down to a battle between those who want the spectrum reserved for closed mobile uses and those who want it for TV, links, research, and private nets. Those heard in the past two weeks include power companies, police and forestry services, highway groups, aviation people, and a microwave council.

Airways Planning

The Washington air has been filled lately with all kinds of plans for the national airways. President Eisenhower has sent a bill to Congress that will establish the Air Modernization Board. This Board will have some of the basic responsibilities of the Air Navigation and Development Board, except that a large degree of authority will go along. Something the ANDB never had. The plan was suggested by Edward P. Curtis, the President's Special Assistant.

In essence, the Board will be set up for a three-year term to start modernization of the airways. Thereafter, it is hoped that a permanent independent agency would be established to take over. It would be charged with first of all getting existing airports and control functions equal to the demands of present traffic. Part of the job will include research and recommendations on the kinds of equipment and systems that should be incorporated.

Meanwhile, James Pyle introduced a new 6-year plan for the Civil Aeronautics Administration. His plan calls for the total expenditure of some $810 million and a three-fold increase in personnel within that time. Once Curtis' plan gets going, he estimates it will cost between $35 and $50 million a year to operate. The CAA plan calls for a tremendous expenditure for radar and communications equipment. The tenure of the program also allows for implementation by any new equipment that may come along. On a yearly basis, the CAA expects to spend as little as $77 million and as much as $202 million. This year, the agency is allowed to spend $75 million—and it is having a hard time getting manufacturers to take its orders. Being a civil agency, it must stand in line behind the military branches for electronic equipment.

Finally, the Air Coordinating Committee—the group that decided to combine VOR and TACAN

into VORTAC for both civil and military use—brought out a 107-page document called "Accelerated Modernization of the U.S. Air Traffic Control and Navigation System." This document makes a thorough study of existing conditions and makes some recommendations. Fortunately, the ACC, Curtis, and the CAA have been working very closely and all three proposals and plans complement each other. With such a three-pronged attack, things should start looking up for the airports around the country—at least within the next five or six years.

Semiconductor People Fear Increased Demand

Most design engineers have become resigned to waiting for the special semiconductors they ordered months ago. But the manufacturers of these units are much more concerned. One sore point is the scarcity of high purity tantalum. Delivery schedule is about 48 weeks. And without tantalum, the manufacturers cannot make power silicon diodes to meet reliability requirements.

Molybdenum sheet deliveries also are delayed. And argon gas has been especially short ever since two of its chief manufacturers went on strike some time ago. All in all, the semiconductor manufacturers, seeing that things are tough now, wonder what will happen when the demand for their products reaches the size estimated by certain experts—nearly a $250-million business in three to five years.

Satellite Testing Progresses

The Navy Department, particularly NRL, is moving right ahead with its testing program for the earth satellite. A two-stage Viking rocket was fired successfully recently to demonstrate how part of the launching portion will work. A GE engine was also accepted that will fit into the second stage. Aerobee-Hi rockets have been sent aloft carrying satellite instrumentation. One Aerobee climbed to between 180 and 200 miles to prove that it could be done. And the Navy has asked Congress to add to the $50 million already spent or committed.

The project is expensive and some deliveries have been slow, giving rise to some speculation about success. But oftspoken statements by Dr. John Hagen, Project Director, and Sec'y of the Navy Tom Gates that the satellite might become airborne by December 1958 show that they are going to take full advantage of the 18-month IGY. Within that time they feel confident that at least one of the gold-plated balls will get into an orbit.

From the standpoint of the satellite, the 20 1/2-inch missile is ready. Static tests have been conducted and the detector and Minitrack systems have been proved out as far as the tests could go. And even the instrumentation has been sent up to over 100 miles with no reported kick back. However, putting this mass into an orbit 300 miles above the earth is a tremendous job.

Meetings

June 6-7: First National Symposium on Production Techniques

Hotel Willard, Washington, D. C. Sponsored by the IRE Professional Group on Production Techniques. Discussions will be held on "How to Prepare For and Implement Automation "and "Military Problems in Electronic Automation." Papers will be presented on "Designs for Production." For information, write to IRE, 1 E. 79th St., New York 21, N.Y.

June 8-12: Technical Career Conference

Sherman Hotel, Chicago. Sponsored by the Technical Career Council. For more information write Marcus W. Hinson, Technical Career Council, 19 S. LaSalle St., Chicago 3, Ill.

Reliability Symposium

June 10-11: Second RETMA Symposium on Applied Reliability

Syracuse, N.Y., Hotel Syracuse. Symposium emphasizes the practical aspects of achieving reliability. Sessions will be held on mechanical design, selection and use of components, proof of mature design and case histories of reliable and unreliable designs. Papers of special interest to electronic designers are included below.

Selection and Use of Components Tues. a.m., June 10

CHOOSING BETTER ELECTRONIC PARTS. *Capt. H. E. Bernstein (USN Ret.), RETMA.*
APPLICATION EVALUATION OF ELECTRONIC PARTS. *W. Barron, Bell Aircraft Corp.*
HEAT DISSIPATION IN ELECTRON TUBES. *W. Campbell, Naval Electronics Laboratory.*
APPLICATIONS AND RELIABILITY ASPECTS OF RELAYS. *D. Shuchard, S. H. Couch Co.*
COMPONENT PART APPLICATION ENGINEERING FOR RELIABILITY. *G. Brown, Inland Testing Laboratory.*

Techniques of Mechanical Design Tues. p.m., June 10

Environmental Factors Affecting Reliability of Electronic Equipment Vibration Problems in the Design of Shipboard Electronic Equipment (film) narrated by Mr. John L. Eitel, Naval Electronics Labs.
TARGET RELIABILITY. *Paul F. G. Holst and Louis R. Zimov, Crosley Division, AVCO Mfg. Corp.*
MECHANICAL DESIGN FEATURES OF A RADAR FOR THE MILITARY SERVICES. *Leonard Jacobs, Radio Corp. of America.*

PLUG-IN UNITS AS AN AID TO RELIABILITY. *R. B. Bonney, Electronic Engineer Co. California.*
PROCEDURES TO ACHIEVE MATURE DESIGN. *Rex Clark, Royal Scientific Services British Admiralty.*

Proof of Design
Wed. a.m., June 11

RELIABLE SYSTEM DESIGN. *M. M. Tall and S. M. Sherman, Radio Corp. America.*
FAILURE PREDICTION TECHNIQUES APPLIED TO RADAR DESIGN. *F. L. Scripture, American Machine & Foundry Co.*
THE ENGINEERING OF RELIABLE DESIGN. *E. R. Jervis, Aeronautical Radio Inc.*
RELIABILITY MEASUREMENT OF MATURE DESIGN. *R. R. Landers, General Electric Co.*

Case Histories
Wed. p.m., June 11

Case histories of the following equipment will be described: ARC 21; AN/FSQ7; APN-70; and TACAN.

A panel discussion is planned on industry vs. military responsibility on contract and specification control for reliability. Advance registrations will be handled by the RETMA Engineering Office, Rm. 650, 11 W. 42nd St., New York 36, N.Y.

June 10-14: Fifth Annual Technical Writers' Institute

Rensselaer Polytechnic Institute, Troy, N.Y. Designed for those who supervise technical writing in business, industry and the professions. Sessions on manuals and instruction books, reports, technical promotion, training programs, industrial films and graphic and illustrative aids. For additional information, write Jay R. Gould, Director, Technical Writers' Institute, Rensselaer Polytechnic Institute, Troy, N.Y.

June 13-15: Third National Symposium on Instrumental Methods of Analysis and Analytical Instruments Clinic

University of Chicago. Sponsored by the Instrument Society of America. For advance programs and registration information, write to H. S. Kindler, Director of Technical Programs, Instrument Society of America, 313 Sixth Ave., Pittsburgh 22, Pa.

Military Electronics

June 17-19: 1957 National Convention on Military Electronics

Sheraton-Park Hotel, Washington, D. C. The theme of the convention is "Missiles and Electronics." Both unclassified and classified papers are being presented. The sponsor is the Professional Group on Military Electronics, IRE. There will be exhibits. The following topics will be covered:

Meetings

Mon. p.m., June 17

1. Design Goals for Future Missile System Electronics.
2. Instrumentation and Telemetry.
3. Mechanical Design for Reliability.
4. Circuitry and Subsystems I.

Papers of interest to designers include transistorized telemetering equipment; the design of a wide-band magnetic tap device; cooling (determination of thermal effects, evaporative-gravity cooling); packaging for reliability.

Tues. a.m., June 18

1. Precision Ranging and Tracking I (confidential).
2. Component Parts I.
3. Electrical Interference Avoidance.
4. Test Equipment and Maintenance.

Papers of interest to designers include: component reliability studies; frequency control devices; radiation effects on semiconductor diodes; using transistors and auto-assembly; evaluation and reduction of interference; maintenance techniques and test equipment.

Tues. p.m., June 18

1. Simulation Equipment I (confidential).
2. Component Parts II.
3. Operational Analysis.
4. Computers, Data Links.

Papers on components include high rate batteries; silicon optical systems; ferrite antennas; mechanical filters; magnetic amplifiers.

Wed. a.m., June 19

1. Miscellaneous (confidential).
2. Reliability, Performance and Methods.
3. Simulation Equipment II.
4. Inertial Systems.

The miscellaneous category covers papers on planning instrumentation for weapons systems; infrared detectors; human engineering; developments in inertial instrumentation. Reliability of SAGE and TACAN will be covered. A number of papers on inertial navigation techniques are planned.

Wed. p.m., June 19

1. Guidance Systems (confidential).
2. Circuitry and Subsystems II.
3. Component Assemblies.
4. Ranging and Tracking.

Shunt and series feedback for transistor amplifiers; integrating capacitor problems; variable bandwidth servos; power supplies; antenna miniaturization; striplines; and modulator designs are a few topics covered in these sessions.

Address all correspondence to George Rappaport, Emerson Radio and Phonograph Corp., 701 Lamont St., N.W., Washington 10, D.C.

June 24-28: Summer General Meeting and 73rd Annual Meeting, AIEE
Sheraton-Mount Royal Hotel, Montreal, Que. An opening day session will deal largely with the Canadian Transcontinental Microwave system and papers concerning nucleonics. Other papers will cover radio communications, suburban electrification, dielectrics, magnetic amplifiers, safety, land transportation, telegraph systems, the textile industry, power generation, transmission and distribution, computers, communications theory, research and industrial control. For further information write to AIEE, 33 W. 39th St., New York N.Y.

June 27-29: Thirteenth Annual Meeting, Institute of Navigation
Sheraton-Park Hotel, Washington, D.C. The comprehensive program will deal with the problems of air and marine navigation and special navigation problems. There will also be a symposium on the question of a common air-marine system of navigation. For more information, write to Brig. Gen. Peter C. Sandretto, Federal Telecommunication Laboratories, Nutley, N.J.

Aug. 20-23: Wescon (Western Electronic Show and Convention)
Cow Palace, San Francisco, Calif. Sponsored by the San Francisco and Los Angeles Sections representing the Seventh Region IRE and West Coast Electronic Manufacturers Association. For more information write to Don Larson, Business Manager, 342 N. LaBrea Ave., Los Angeles 36, Calif. For those interested in submitting papers, check the paper deadlines at the end of this section.

Sept. 4-6: Special Technical Conference on Magnetic Amplifiers
Penn Sheraton Hotel, Pittsburgh, Pa. Sponsored by the AIEE and the IRE. The program's four sessions will deal with New Circuits and Techniques, Analysis and Design, and Applications. For more information, write to D. Feldman, Bell Telephone Labs.

Paper Deadlines
July 1: Deadline for technical papers to be presented at the 1957 national conference of the IRE Professional Group on Vehicular Communications. The meeting is to be held December 4 to 5 at the Hotel Statler in Washington, D.C. The central theme for the conference is "Meeting the Demands for Vehicular Communications." Submit brief descriptions of proposed papers to Committee Chairman Grant E. Woodside, Jr., Motorola Communications & Electronics, Inc., 1145 19th St., N.W., Washington 6, D.C., before July 1.

Aug. 1: Deadline for papers proposed for the Oct. 31-Nov. 1 conference of the **Professional Group on Electronic Devices, IRE,** in Washington, D.C. Abstracts should be submitted to the program chairman, W. M. Webster, RCA Semiconductor Div., Somerville, N.J. Subject matter should concern developmental techniques and devices, such as electron tubes and transistors, rather than basic research or circuit applications.

Background For Designers

FERRITES—1957

Lawrence G. Rubin
Research Division
Raytheon Manufacturing Company
Waltham, Mass.

FERRITES are among the most interesting of the new materials being applied to electronic equipment. They have a large and increasing number of applications because they permit accomplishments not feasible with any other known material. Generally speaking, ferrites are useful in devices where high resistivity is of great importance, while a somewhat low value of induction is not a great disadvantage. Of greater long range value is their versatility, which arises from the types and combinations of different electrical and magnetic properties which may be built into the materials. The possibility of producing the commonly required shapes and sizes by well known ceramic techniques has been fully exploited to yield ferrite bodies with good uniformity, easy manufacture and low cost.

Any attempt to bring the story of ferrites to the attention of circuit and component design engineers must be guided by two salient factors: *1.* There has been a tendency for a large gap to develop between the basic research and investigation of the properties of matter and the incorporation of that matter into practical electronic devices. The design engineer, who is responsible for the second phase, cannot be expected to be able to take full advantage of the capabilities of a given material unless he is at least somewhat familiar with the general background and basic properties of that material; 2. The eagerness of these same design engineers to capitalize on the advantages of ferrites has led to their use in many and diverse applications, e.g., in the high quality coils and transformers of radio, television and tele-communication engineering, in antenna cores, in memory cores for digital computers, in magnetostrictive filters and oscillators, in recording heads, and in microwave devices such as phase shifters, isolators, and circulators. Represented therein are many specialized areas of electronics where ferrites are used.

In consideration of the first factor, this paper will briefly deal with the composition and material properties of ferrites, i.e., present general background for the design engineer. As for the second factor, it is believed that an appreciation of the versatility and capabilities of these materials might lead to new ideas for their use as well as to a better understanding of the problems faced by the research scientist who is trying to control many material parameters reproducibly and over a wide range. Therefore, an attempt will be made to cover as many different fields of application as possible, with particular emphasis on those considered to be of greatest importance: cores for radio-frequency devices (the materials for which constitute the major portion of the present commercial output of ferrites); rectangular hysteresis loop toroids for high speed switching; and microwave devices covering a frequency range of tens of kilomegacycles.

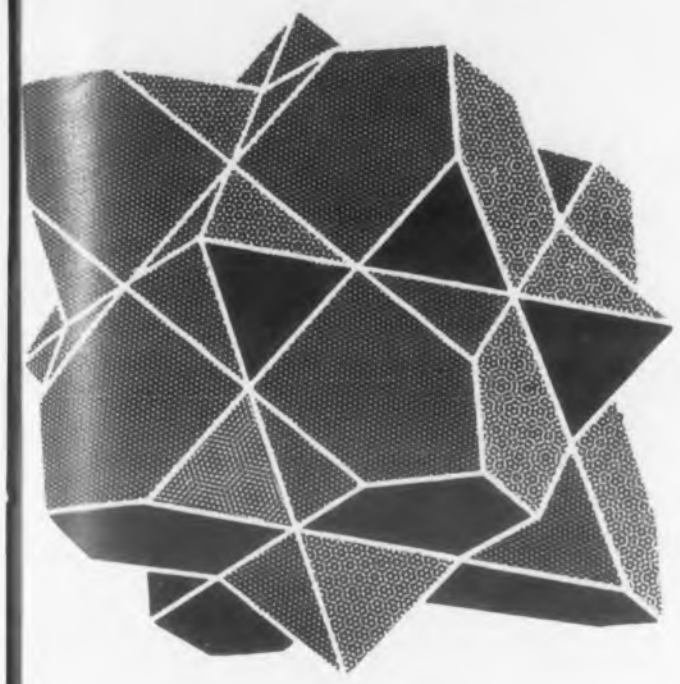
NATURALLY occurring in nature, magnetite $Fe^{+2}O{\cdot}Fe_2^{+3}O_3$, has to be accorded the honor of being the first ferrite, despite the fact that its electrical and magnetic properties leave much to be desired. By substituting certain other atoms for the divalent iron (Fe^{+2}), it is possible to preserve the basic crystal structure of magnetite (the so-called "spinel" type) and obtain increased values of permeability and resistivity. The substitute atoms, which must be about the same diameter as the iron atom they replace, include magnesium, manganese, nickel, cobalt, zinc, cadmium and copper. The properties of the resulting ferrites are dependent on the kind and proportions of the substituted metal atoms and on their geometrical arrangement in the spinel structure. In addition, the properties are strongly influenced by other factors, including purity of the constituents together with ceramic processing techniques such as forming and firing, which control homogeneity, porosity, microscopic grain structure, phase relationships and the degree of internal strain.

Categories

Because of the many varieties of ferrites which are now commercially available or may soon become so, it might be helpful to categorize them by composition and subsequently correlate these categories with specific areas of application. However, since the variations in composition are almost unlimited, such a list ought to include only the most typical and popular ferrites for the sake of convenience. Seven classes of ferrites have thus been chosen and are listed in Table I in terms of the principal atoms substituted for iron in magnetite.

As has been implied previously, the existence of such a large family of ferrite materials has led to a wide range of available magnetic and electrical properties. Sime of the properties in which we will be interested are as follows: *1.* initial permeability, $\mu_0 = B/H$ for very small H; *2.* maximum permeability, $\mu_m = B/H$ at knee of magnetization curve: *3.* coercive force, H_c in oersteds = intercept of hysteresis loop on H axis; *4.* remanent induction or residual flux density B_r in gauss = intercept of hysteresis loop on B axis; *5.* saturation flux density B_s in gauss = maximum obtainable flux density entrapolated to zero field; *6.* material product μQ^2; *7.* Curie temperature T_c in degrees C = temperature above which the ferrite loses its ferromagnetic properties; *8.* volume resistivity ρ in ohm-cm.

There are many other parameters, some of which will be discussed in connection with the rectangular loop and microwave uses of ferrites. However, there is now enough background to enable us to put some numbers in and see just how ferrites are put to use.



Permeabilities

The initial permeability of ferrites ranges from about 10 for some type III to about 5,000 for some type I ferrites. This compares very favorably with the μ_o of powdered metals, which seldom exceeds one hundred. On the other hand, some iron alloys (80 per cent nickel) attain values of 20,000 to 100,000; while this represents quite a difference, it should be pointed out that ferrites are already on a par with lower nickel content (50 per cent) iron alloys and are well ahead of the normal hot-rolled silicon iron (μ_o = 500 to 1500).

The maximum permeability is somewhat dependent on μ_o and by definition, of course, is always larger than μ_o. However, some materials having a fairly small μ_o can reach a μ_m of large magnitude, while other materials showing a high μ_o may have a μ_m only slightly larger than this. The range of variation of μ_m is from about 100 for some type III to just over 10,000 for some type I ferrites. The latter value is higher than that of hot-rolled silicon iron but far removed from the 100,000 to 1,000,000 attainable in the high nickel-iron alloys.

Table I. Ferrite Types, Showing Principle Material Atoms Substituted For Iron In Magnetite.

FERRITE CLASS	MATERIAL ATOMS SUBSTITUTED
I.*	Nickel; Zinc
II.*	Manganese; Zinc
III.	Nickel
IV.	Barium[1]
V.	Manganese; Magnesium
VI.	Nickel; Cobalt
VII.	Aluminum; Nickel or Magnesium

* may contain small amounts of copper, cobalt, magnesium or others

Saturation Flux Densities

For most ferrites, values of saturation flux density are grouped in the range of 2,000 to 4,000 gausses. Some type II ferrites may run up to 5,000 gausses, but this is still well below the 18,000 gausses of silicon iron. These figures demonstrate the reason for the wording of the introduction of this paper, concerning the generally low value of induction to be expected in ferrites. This limitation imposes a restriction on their use in power transformers or other devices operating at high flux levels, because of the large core volume required.

B and H Intercepts

To complete the parameters describing the hysteresis loop, there remain the intercepts B_r and H_c. The former may range from 400 (type I) to almost 4,000 for the type IV, a representative of the "hard" ferrite material family. For some applications the ratio B_r/B_s is of more importance than B_r itself; thus, the fact that in some type V ferrites this ratio is greater than 0.9 is of interest to memory core design engineers, while a ratio as low as 0.3 makes feasible the control of a highly variable inductance through the use of a low power dc winding. The values of H_c range from about 0.05 oe for some type I to about 10 oe for some type III ferrites. As might be expected, an exception exists for the hard type IV ferrites, where H_c may reach 2,000 oe. At this juncture, it is convenient to point out that type IV ferrites for permanent magnet applications are obtainable with a peak energy product BH as high as 3.5×16^6, comparable to that of Alnico V on an equivalent weight basis. It should be noted, however, that operation at the peak energy product is obtained at values of H much larger than, and B much smaller than, Alinico V. This means that the type IV ferrites will have a very high resistance to demagnetizing influences.

High Mu • Q

The large scale use of ferrites as core material in radio frequency devices is a result of their large values of μQ obtainable at frequencies up to many megacycles. In this respect, types I and II ferrites are superior to the laminates used for similar purposes. Specifically, type II ferrites may exhibit a μQ of 5×10^5 at 10 kc. and it may remain greater than 10^5 up to several hundred kc. It is almost an order of magnitude higher than that of iron powders or iron alloy tapes at 100 kc. However, the Q of types I and II ferrites tends to fall off rapidly near 1 Mc., so that μQ is down to several hundred by 10 Mc. Type III ferrites are reported to have practically constant, though relatively low, values of μQ (2,000) through the frequency range up to 10 Mc. We are faced here with the compromise so familiar to design engineers—at high frequencies, we can obtain high permeability only at the expense of low Q, and vice versa.

Core Losses

The total losses of a coil due to its ferromagnetic core are of three kinds: hysteresis, eddy current and residual losses. Most ferrites have negligible eddy current losses because of their high volume resistivity, which may run up to 10^{11} ohm-cm. The fact that the resistivity of some ferrites (types I and II) is as low as 10 to 100 ohm-cm is not serious, considering that even these values are still 10^5 to 10^7 times larger than those of metallic magnetic materials. At frequencies well below that at which μQ begins to decrease rapidly, the hysteresis losses of ferrites predominate, the type I and II ferrites showing the least such losses. However, above that frequency the residual losses become predominant. These losses are attributed to both microscopic and macroscopic causes including domain wall resonance (relaxation), ferromagnetic resonance and dimensional resonance. No further comments will be made concerning residual losses, except to point out that since they are of prime importance in the microwave uses of ferrites, a great deal of experimental and theoretical work is being done to explain them and to lessen their effects.

Curie Temperatures

The Curie temperatures of ferrites range from 70C for some type I ferrites to about 600C for type III. This parameter is far more important in the device application of ferrites than it might seem simply on the basis of "they will work below T_c and will not work above T_c." The fact is that it is typical of most magnetic materials that the initial permeability increases with rising tepremature to a peak value just below the Curie temperature. The high permeability realized in some of the ferrites is due largely to the fact that they have Curie temperatures near room temperature and are used near the peak permeability. This condition tends to produce high sensitivity of permeability and other properties to temperature variations.[3]

Other Parameters

The problem of temperature stability of ferrites should be neither over- nor under-emphasized. The primary responsibility of the design engineer is to consider the particular application—the range frequencies involved, the permeability desired and the permissible losses, along with the sort of temperature stability required and to choose the particular composition which most nearly meets specs.

As a further note on ferrite properties, it should be realized that ferrites have high values of dielectric constant. In some ferrites, apparent dielectric constants over 100,000 are measured at voice frequencies. The dielectric constant decreases with an increase in frequency approaching a value of near 10 at microwave frequencies.

FERRITE APPLICATIONS

Low Frequency

Television

For television, a description of specific applications of ferrites might well begin with that which uses the major part of the tonnage of ferrite production—fly-back transformers and deflection yokes in television circuits. In this application, the magnetic requirements are primarily high permeability at the sweep frequency (15 kc), low loss at the fly-back frequency (up to 100 kc) and stability at temperatures encountered in television sets. Proper utilization of the capabilities of types I and II ferrites has led to improved sweeps, smaller size and greater economy.

Transformers and Filters

The high initial permeability and Q factor of ferrites at frequencies up to about 1 Mc leads to their use in antenna cores, i.f. transformers and filter inductors. In these and other similar applications, effective use is made of air gaps inserted into the magnetic core path. These gaps serve to reduce the instability of permeability due to mechanical or magnetic shock and to temperature variations. They also make it possible to optimize the Q value of the coil.[4] Interestingly enough, a ferrite core with air gaps exhibits an effective permeability not much higher than that of the powdered metal core it may have replaced. However, the high true permeability of the material enables the core to furnish excellent magnetic shielding for the component, particularly if properly shaped cup cores are used.

In many cases air gaps are not wanted; for example, when it is desired to assemble the core from parts but yet retain a high permeability. It is possible to take two halves of a ferrite core and grind the contiguous surfaces so smooth that when placed together they will form a core having the same permeability as a continuous closed magnetic path of the same dimensions. This permits winding of cores on bobbin winding machines and eliminates the need for expensive toroidal windings.

Electro-Mechanical Transducers

The magnetostrictive effect in ferrites can be used to produce electro-mechanical transducers, as well as sharply tuned circuit elements such as filters. The material constants are such that elements (toroids or rods) of the size of the order of 1 in. have a mechanical resonance at frequencies in the 100 kc range. Coupling coefficients are of the order of 0.20 to 0.30; the mechanical Q tends to be high—in the range 1000 to 5000. The widely available type I and III ferrites appear to be satisfactory for many applications where high resistivity and ease of manufacture would prove advantageous (replacement of nickel laminations, etc.).

Magnetic Tape Recorders

As a final example of the lower frequency uses of ferrites, we have the magnetic tape recording field. Magnetic ferrite "heads" (for recording, reproducing and erasing) are found to be advantageous in many respects. They are harder than metal heads (reducing the wear problem), they can be easily fabricated in the desired shapes and to precise tolerances (simplifying and improving the tape systems), and they are better suited to higher erase frequencies (which give more complete erasure and hence better quality recordings upon re-use). Types I and II ferrites appear suitable for this application.

High Frequency

Computers

Another prominent present day application of ferrites is their use in high speed computers. In these machines, ferrite toroids are utilized for storage of binary information in coincident current memory arrays. They provide high speed, inexpensive, arbitrary access memory with the stability and reliability required. They are faster than megnetic drums, more flexible than acoustic delay line storage units, and are simpler and easier to maintain than electrostatic storage tubes. Toroids with slightly different characteristics are also used for switching the memory array cores.

In specifying properties for switch and memory cores, we might include the following: switching time less than 1 microsecond; low coercive force; high values of B_r/B_s ($\gtrsim 0.9$) and of B_s itself; high squareness ratio, which means sufficiently slight response to one-half pulse (in two-dimensional memory) or two-third pulse (in three-dimensional memory) for unambiguous core selection. Such properties are required to provide two identifiable states of remanent magnetization as well as a highly non-linear B-H realtionship so that the state of magnetization can be definitely and quickly changed. The degree of rectangularity and the uniformity and stability of characteristics have a direct bearing upon the number of cores which can be used reliably in a memory, and hence upon the storage capacity of the memory.

The type V ferrites which, like all ferrites, may be fabricated in many shapes and sizes, including tiny rings (1/16 inch diameter or smaller), seem to provide us with the answers to most of our memory core problems. It is true that the coercive force H_c is larger than we would like it to be (1 to 1.5 oersteds), but this is in a sense the price paid for the very fast switching time. Where the latter requirement is less stringent, it is possible to produce materials of considerably smaller coercive force. Such materials are useful in pulse transformers and magnetic amplifiers.

As many design engineers working in this field have discovered, specification of properties such as squareness ratio is not sufficient to insure satisfactory results. To properly evaluate ferrite toroids for the memory application, pulse tests are often designed to subject a single toroid to the conditions that might be encountered in an operating array. For example, it is important to know the smallest possible voltage obtainable from a selected toroid holding a one ($+B_r$) and the largest possible voltage from a selected toroid holding a zero ($-B_r$).

It would not be proper to end our discussion of rectangular loop applications without pointing out that the properties of interest are extremely structure sensitive, and very careful control of the processing variables is required for consistent output of cores of high quality.

Microwaves

Among their other ferromagnetic properties, ferrites exhibit a strong Faraday Effect. This phenomenon was first observed by Faraday in 1848 when he passed a plane polarized light beam through a thin sheet of magnetic material magnetized in the direction of propagation. What he observed with light has also been observed in the microwave region. The plane of polarization is rotated in passing through the medium, the angle of rotation being proportional to the thickness of material traversed and is a function of the strength of the magnetic field. The direction of rotation of the plane of polarization depends only on the *direction* of the applied static magnetic field. This rotation is thus non-reciprocal since the angle of rotation would be doubled if the beam is reflected back along its path.

Gyrators, Isolators and Phase Shifters

The non-reciprocal properties of ferrites have made possible several types of devices including gyrators, circulators, isolators and phase shifters. Other phenomena exhibited by ferrites in waveguide, such as resonance absorption and field displacement effect, are also extremely useful in isolators. It should also be pointed out that many of the devices mentioned above can be made reciprocal—through proper arrangement of the ferrite pieces in the guide for example.

There are many problems faced by the design engineer in the microwave device field. They include those of extending the usefulness of ferrite devices over a wide frequency range; broad banding some of these devices in terms of the ferrite elements themselves; obtaining satisfactory operation at high power levels; and finally, choosing that waveguide geometry and ferrite characteristic (resonance absorption, field displacement, Faraday rotation, etc.) which will best suit his requirements.

X-Band Devices

Until recently, most interest in the microwave device field was centered on X-band frequencies, where type V ferrites have proven useful. While the

ferromagnetic resonance losses are comparatively broad in this region, they do not have a large effect at the values of bias field used in phase shift (or rotation) devices. However, in high power applications (for example, more than two hundred watts average power) these small losses become important, it even being possible to heat the material above its Curie temperature. Type III ferrites will give the advantage of high Curie temperature (about 600C, compared to 250C for type V ferrites). However, they are lossy in the partially magnetized state, and thus cannot be used very well in devices requiring rotation proportional to applied field.

Materials of the type VI classification are under development in various laboratories for the purpose of providing materials with narrow resonance absorption regions and with high Curie temperature. Resonance line width represents one of the most important considerations in the preparation of ferrite material for certain microwave devices. The optimum operation of these devices will require that the loss associated with ferromagnetic resonance must be minimized in at least one direction of transmission. This condition can be achieved only through the use of ferrite materials with narrow resonance line widths.

There seems to be no reason to believe that X-band ferrites will not be satisfactory in the region of frequencies above this (Ku-band, K-band, etc.). Indeed, the loss due to ferromagnetic resonance, which is believed to be of importance at X-band, will be decreased. Unfortunately, this situation works against us when we consider frequencies below X-band—resonance losses are quite troublesome at S-band, for example. Some type VII ferrites have made possible the construction of isolators in this region, but these materials have the disadvantage of low Curie temperatures, possibly of the order of 150 C.

Lower Frequency Devices

Still lower frequencies, down to 400 mc are of interest at present. At these low frequencies, the ferromagnetic resonance losses are even more serious. Furthermore, although dielectric and low field magnetic losses may be minimized and even eliminated (in principal) it becomes increasingly more difficult to do so. The effect of these is, in general, to make any given ferrite useful only above a certain frequency. This lower frequency limit will, however, depend upon the type of device.

Extrapolations can be made from experience at higher frequencies, and these had originally led some investigators to claim that even with the furthest development of materials, there would be a lower frequency limit for devices of the isolator type at about 1,000 mc. However, improvements in materials have come along to aid us, as attested to by results from the author's laboratory, where a type VII ferrite has been made to provide isolation with a 30:1 back-to-forward ratio at about 1200 mc.

In general, it is usually assumed that details of ceramic preparation affect the loss considerably, and much effort of an empirical sort has gone into studies of these effects. A great body of experimental information has been obtained in recent years on the behavior and design of ferrite components and, to a lesser extent, some theoretical work has been done to explain the behavior of these devices. The net effect of this work will undoubtedly be to provide the design engineer with improved materials as well as a better understanding of the principles governing their operation in devices.

The availability of ferrite materials suitable for use in microwave devices should be commented on since the situation is different from that existing with other types of ferrites. There is a large and increasing number of companies selling completed microwave devices (waveguide components incorporating ferrites, magnets, loads, etc.). However, it it comparatively difficult for the microwave design engineer to procure ferrites with well-defined microwave properties for his own applications. This situation is at least partly the fault of the engineer, who has not made clear to the manufacturer what it is he *does* want. In a new field, this is always a problem, but it is expected that this status will be improved upon in the near future.

CONCLUSION

This paper has attempted to describe the ferrite field on the basis of all of the results available at present without regard to source. All material collected here has appeared elsewhere in one form or another and has been made use of if believed to be of value in this presentation. For those readers who are anxious to obtain further information, the October 1956 issue of the Proceedings of the IRE (vol. 44, No. 10) contains a number of excellent articles on the subject of ferrites. In addition, a wealth of technical data exists in the literature furnished by ferrite manufacturers. A listing of some of these companies is in Table II, together with some of the types of ferrites they produce. The list includes only those companies which sell ferrite *materials* for use outside their own organization.

References

[1] Barium ferrite is a member of the hexagonal, rather than the spinel crystal structure family.

[2] It is often convenient to use the complex notation for permeability $\mu = \mu' - j\mu''$. Here μ' is the usual permeability, and μ'' is proportional to the loss per cycle; the loss angle tan $\delta = \mu''/\mu'$ or quality factor $Q = 1/\tan \delta$ are commonly used. However, when considering coils or transformers using ferrite or, more generally, ferromagnetic cores, Q becomes a figure (the familiar ω L/R) expressing the losses of the core and coil, with a dependance on shape and size. The product μQ (or more precisely $\mu' Q = \mu'^2/\mu''$), on the other hand, has been found to be a useful index of efficiency for design applications since it stays fairly constant for a given material used in different cores.

[3] Ferrites are, of course, semiconductors. As a result, their resistivity will decrease exponentially with a rise in temperature. Where high temperatures are involved, this decrease may be sufficient to lead to large eddy current losses.

The optimum value of μ, as well as the optimum inductor Q, is proportional to the $\sqrt{\mu Q}$ of the core material.

Table II. Ferrite Manufacturers

Company	Product Designations	Types of Ferrites Produced (by application)
H. L. Crowley & Co., Inc. West Orange, N. J.	"Croloy" "Cromag"	RF, PM
Ferroxcube Corporation of America New York, N. Y.	"Ferroxcube" "Ferroxdure"	RF, RL, M, PM
General Ceramics Corporation Keasbey, N. J.	"Ferramic"	RF, RL, M
Indiana Steel Products Co. Valparaiso, Ind.	"Indox"	PM
Radio Corp. of America Camden, N. J.		RF, RL
Raytheon Manufacturing Co. Ceramic Sales Waltham, Mass.	R-151	M
Stackpole Carbon Co. St. Marys, Pa.	"Ceramag"	RF
D. M. Steward Manufacturing Co. Chattanooga, Tenn.	"Lavite"	RF
International Telemeter Corp. Los Angeles, Calif.		RL
Trans-Tech		M

— Code —

RF — Radio Frequency Applications
RL — Rectangular Loop Applications
M — Microwave Applications
PM — Permanent Magnet Applications

Heater Voltage-Current Relationships

Andrew Szilasi
Westinghouse Electric Corporation
Electronic Tube Division
Bath, New York

HEATERS in electronic tubes act as nonlinear resistances, and any given percentage change in voltage produces a different percentage change in current. For many years only the vacuum tube design engineers bothered about this relationship, while the users accepted the fact that a nonlinear relationship existed between heater voltage and heater current.

The law governing this relationship apparently is not known to many circuit design engineers. In any case, due to this lack of information many recent specifications concerning tests at higher or lower heater voltage are contradictory to previous practices. For example, before the arrival of series string heater connections in TV receivers, tests were performed at ±10 per cent of the rated heater voltage. When heater current became the base for tests, many engineers specified variations of 10 per cent in heater current ignoring the non linear heater resistance. They apparently did not realize that ±10 per cent current change corresponds to a much wider range of heater voltage change (and consequently of line voltage). This article shows the relationship of heater voltage vs. heater current.

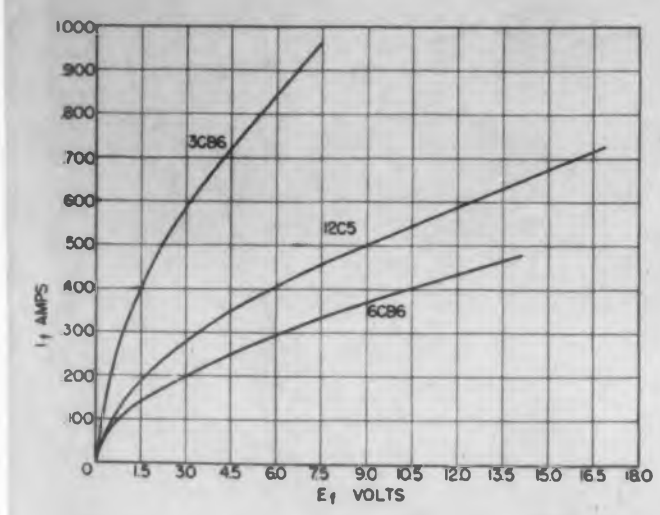
The following curves were produced from four well known types with rated heater voltages ranging from 3.15 v to 50 v. Fig. 1 shows a *3CB6* with heater ratings of 3.15 v and 0.6 amp, the *6CB6* with heater ratings of 6.3 v and 0.3 amp, and the *12C5* with 12.6 v and 0.6 amp. Fig. 2 shows the *50C5* and 50 v and 0.15 amp heater ratings.

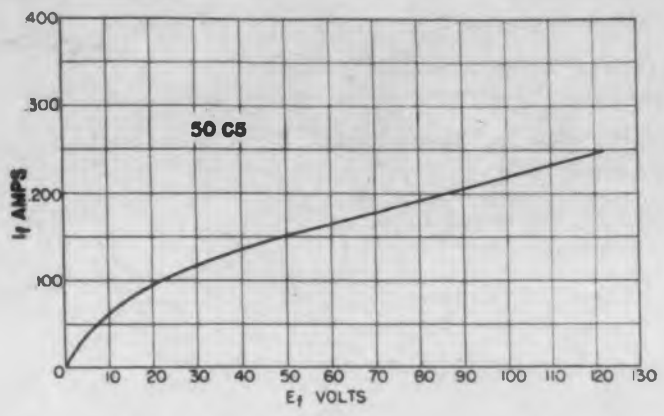
In Fig. 3 the characteristics are redrawn on log-log paper in such a form that all voltage and current values are related to the rated values, giving a linear characteristic, consequently the equation between heater voltage V and current I can be written as:

$$V = C \cdot I^n \qquad (1)$$

where C and n are constants. C varies with the dimensions and the form of the heater, while n corresponds to the temperature dependence of the resistance of the heater wire. This exponent can be deduced in the following way.

By assuming that all heat losses take place by radiation only and that the shielding effect of the surrounding electrodes as cathode, grids, etc. remains constant,





Figs. 1 and 2. Heater voltage-current characteristics on some typical tubes, showing non-linear relationship.

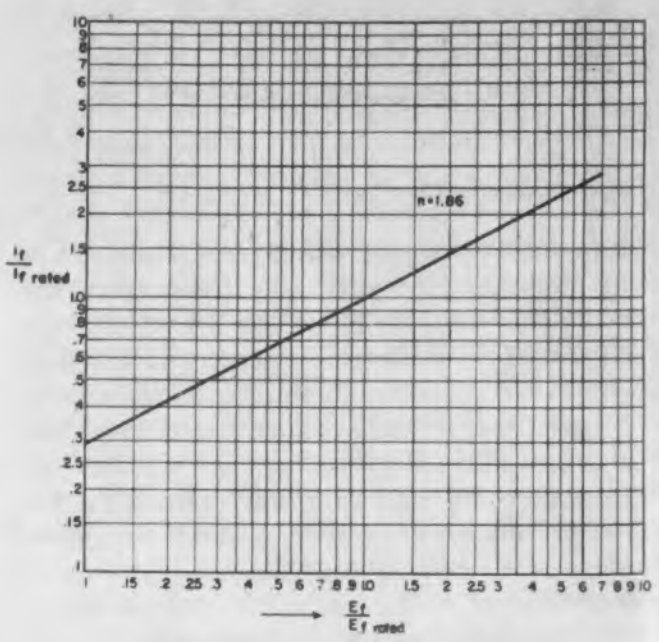


Fig. 3. Normalized voltage-current relationship for typical tube heaters can be used to determine effect of changing either parameter.

$$P = V \cdot I = AT^4 \tag{2}$$

where P is the heater power

A is a constant

T is the heater temperature in degrees Kelvin.

Most of the conventional heaters use tungsten as the conductor. Empirical data are available to show the resistivity of tungsten wire from 300 deg K upwards. This enables us to establish a law between the wire temperature and its resistance. The value of 300 deg K can be considered as room temperature, while the average heater temperature of a vacuum tube is around 1500 deg K.

$$\frac{R}{R_o} = \left(\frac{T}{300}\right)^{1.2} \tag{3}$$

Where R is the hot resistance at temperature T in K degrees, R_o is the heater resistance at 300 deg K and can be calculated for tungsten wire of known length and diameter.

Replacing R by V/I, eq (3) is transformed to:

$$\frac{V}{I} = B \cdot T^{1.2} \tag{4}$$

where B is a constant.

With T eliminated from eq (2) and (4), a function can be derived between V and I producing the value of n sought in eq (1):

$$V = C \cdot I^{1.86} \tag{5}$$

This equation can be expressed also in the following form:

$$\frac{V_1}{V_2} = \left(\frac{I_1}{I_2}\right)^{1.86} \tag{6}$$

where V_1 and V_2 are two different heater voltages applied to the same tube and I_1 and I_2 their corresponding heater currents.

In differential form: .

$$\triangle V = 1.86 \triangle I \tag{7}$$

Consequently, an increase in heater voltage of 10 per cent will produce an increase in heater current of only 5.38 per cent. A useful rough approximation is a value of $n = 2$, with twice as much percentage voltage change as current change.

As an example, a reduction of 10 per cent of the heater voltage for a tube having a rated current of 600 ma will drop the current to approximately 570 ma or, more accurately, to 567 ma.

Fig. 3 gives us the heater characteristic on log-log paper. The line has a slope corresponding to the theoretical value of $n = 1.86$. Extreme values calculated on the basis of the four characteristics in Figs. 1 and 2 show the variation of n to be between 1.77 and 1.93. This proves that the theoretical figure of $n = 1.86$ can be used well in calculating corresponding heater voltages and currents in heater-cathode type receiving tubes.

A Q-Probe for RF Monitoring

Ralph Baer
Vice President
Transitron Electronic Corp.

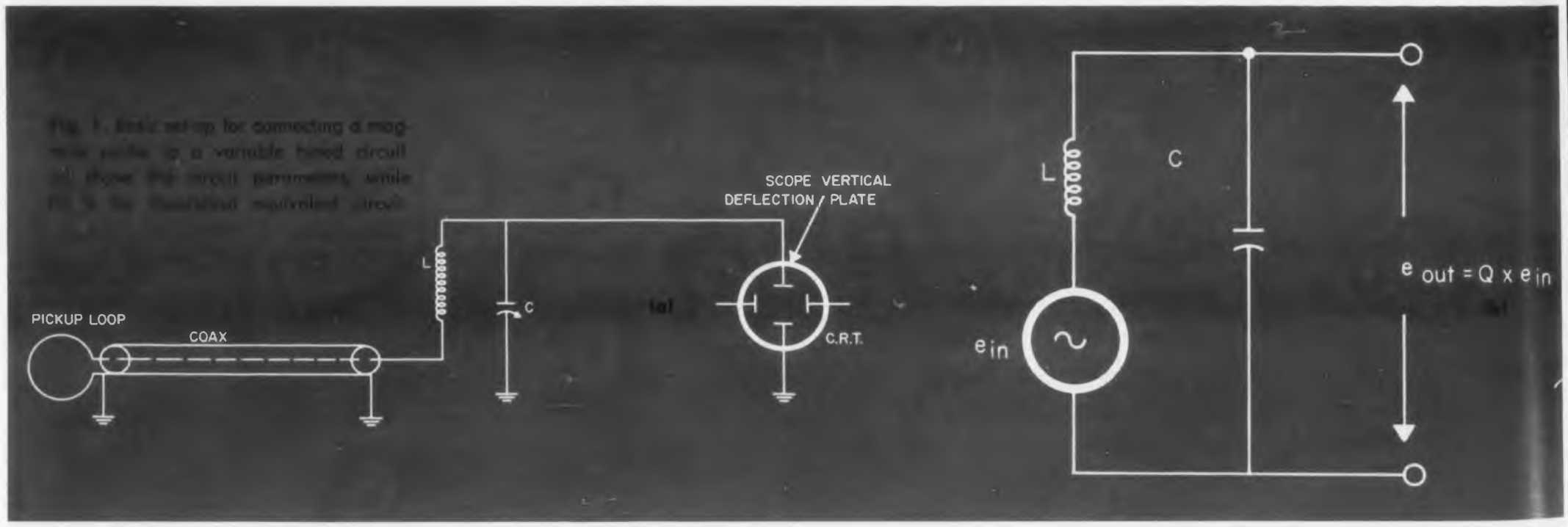
Test unit designed for sampling of rf signals used in conjunction with an oscilloscope, the device permits undistorted display of the signal.

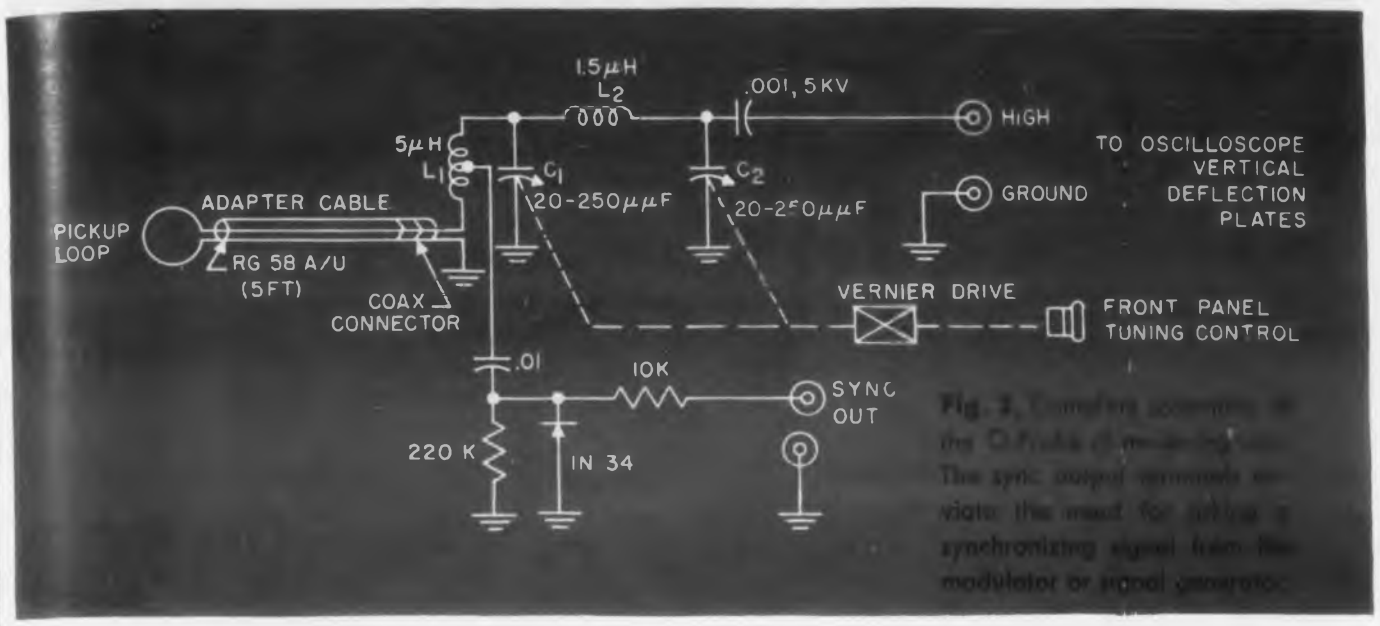
A REALLY simple means of inspecting a transmitter modulator carrier without going through a detection identification process—which may add peculiarities of its own—is obtained through use of the Q-Probe. This test unit is designed to permit sampling of an rf signal and show it on an oscilloscope.

A basic approach to the display of rf waveforms consists simply of running a wire to one of the vertical deflection plates and connecting the free end of this wire to the signal source. In this way, both rf carriers and the envelopes can be viewed. But it is apparent that it takes something like 50 to 100 v peak-to-peak to get a usable display about 1 in. high in this manner. Furthermore, connecting an open wire between the oscilloscope and a high-voltage—and usually fairly high-impedance—rf point changes the conditions at that point beyond all recognition and is frequently dangerous.

The answer lies in taking a sample from the field surrounding the coil carrying the current which we are interested in displaying. A one-turn pickup loop, approximately 3/4 in. in diameter, is just about right: it will get into tight places and can be oriented to discriminate between the fields surrounding several nearby coils. A co-ax cable several feet in length will take the sample of information to the oscilloscope without any problems owing to extraneous pickup. The low impedance level of the one-turn loop will minimize capacitive losses due to cable shunt capacity. However, the signal thus delivered from the co-ax line is at best of the order of 3 or 4 v rf when probing medium power stages. Attempts to get usable signal levels from the cable while probing in such areas as the crystal oscillator result in even less output. Since at least 50 v is needed at the oscilloscope deflection plates, voltage amplification of some sort is evidently required.

To gain useful output from the cable without resorting to amplifiers, a high-Q tuned circuit may be used. Fig. 1(a) shows the basic method for connecting the loop and cable to a tuned circuit which can be adjusted to resonate at the frequency of the signal we wish to look at. Since the loop is a low-impedance source, (a) of Fig. 1 can be re-drawn as in (b), which shows the equivalent circuit. Inspection shows the source to be in series with L and C, hence the voltage across either L or C will be Q





times the applied voltage output from the cable, or

$$e_{cout} = Q \cdot e_{in}$$

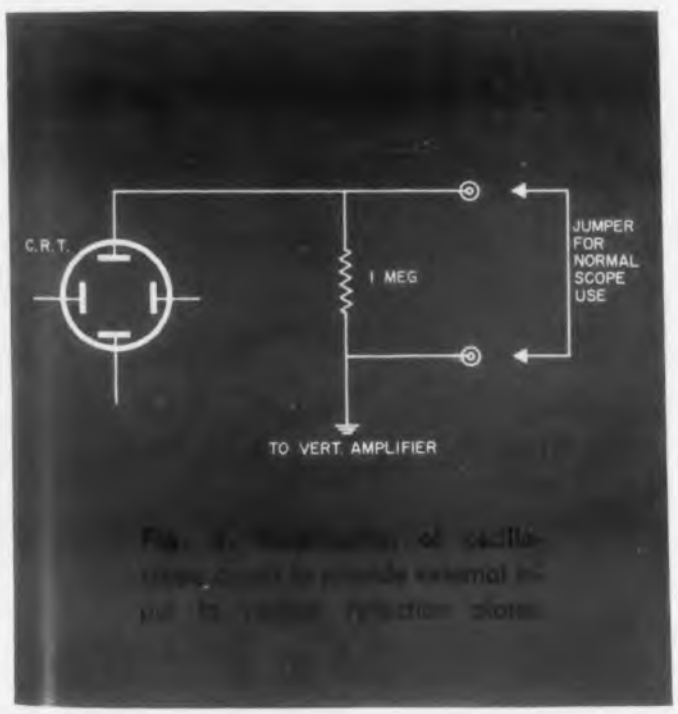
In this arrangement, Q depends primarily upon the quality of the coil L used and to some extent on the characteristics of the loop and cable, especially at frequencies of 20 mc and above. If we now mount coil L with variable capacitor C near our oscilloscope deflection plate connections, we have a workable means for observing rf waveforms. Practical considerations dictate several further requirements. First, it will be found necessary to shield the coil and capacitor to prevent hand-capacity detuning effects. Second, it is necessary to provide some form of bandswitching or plug-in coils to cover the hf communications frequency range from 3 to 50 mc, for which this simple scheme is feasible. Means of synchronizing the oscilloscope sweep with the modulating signal for a stationary display is also required. Such synchronization provisions should be built into the waveform display unit to eliminate the need for extracting a sync signal from the modulator or signal generator, or whatever audio source happens to be in use.

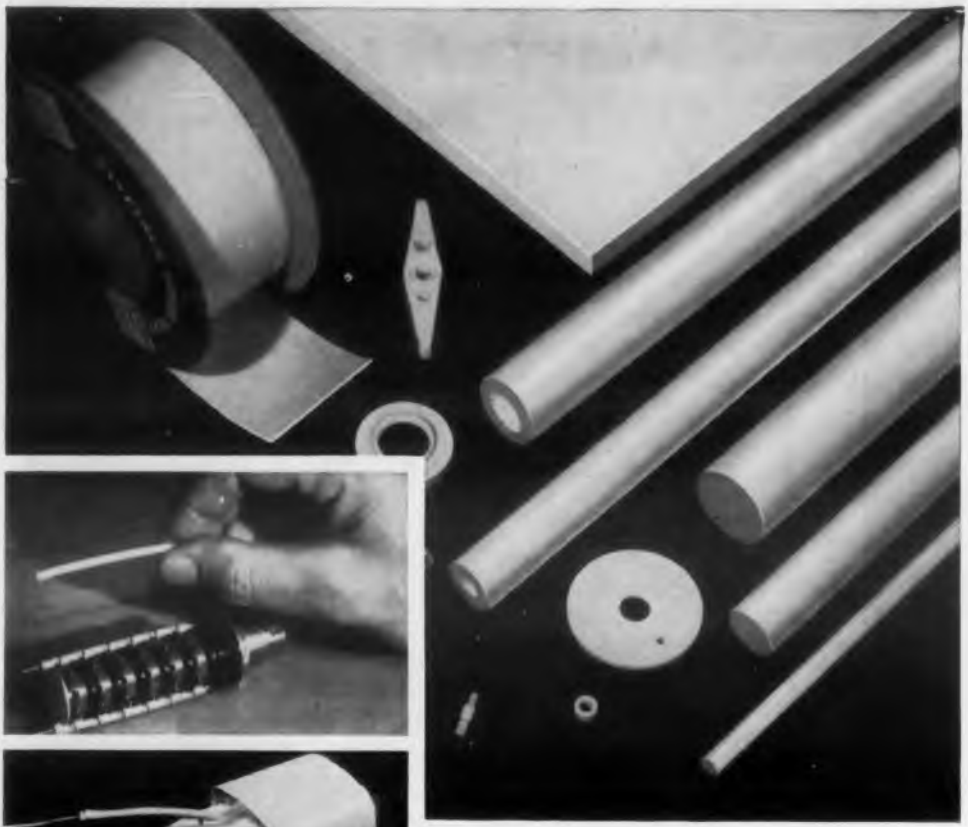
To simplify rf oscilloscope displays, a practical unit based on Fig. 1 should have the following features:

- A fully shielded continuous tuning circuit requiring no plug-in coils or bandswitching.
- A built-in detector capable of developing a sync signal.

The Q-Probe in Fig. 2 combines both of these features. L_1 and L_2, C_1 and C_2 constitute an all-band tuner capable of resonating continuously from 3 to approximately 50 mc. The 1N34 crystal diode detects a small amount of the rf signal across L_1, and delivers the demodulated audio signal to the output terminal through an rf filter. A short jumper to the *ext sync* input of the oscilloscope takes care of the synchronizing problem. A set of bus wire jumpers from the output terminals to a vertical deflection plate and ground will feed the rf signal to the CRT. Allowing the Q-Probe to perch on top of the oscilloscope or right alongside to shorten the bus wire to a few inches, will result in loading the Q-Probe output with less than 10 μμfd. It will consequently give full frequency coverage with most commercial oscilloscopes having externally available binding posts for the deflection plates. Those scopes which do not have such provisions can easily be modified as shown in Fig. 3.

The photographs of Fig. 4 show operating conditions or defects of the equipment from which they were obtained. These displays are obtained by doing little more than tuning the Q-Probe for maximum pattern amplitude and going through the usual synchronization adjustments on the scope.





Polypenco® Teflon stock shapes and fabricated parts. (left below) Aircraft high voltage pulse transformer uses Polypenco Teflon Tape insulation for interlayer, case lining and terminal wrapper. (left above) Polypenco Teflon Spaghetti Tubing used in miniature rotary tap switch combines high dielectric strength in thin sections with resistance to soldering heats.

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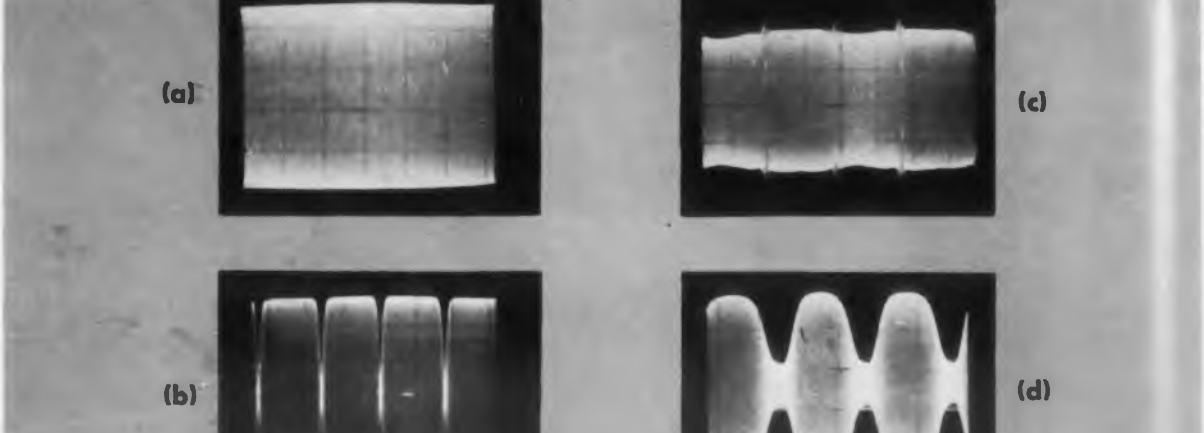
CIRCLE 18 ON READER-SERVICE CARD FOR MORE INFORMATION



Harmonic distortion of individual rf cycles is readily seen as a series of bright lines or bands parallel to the horizontal axis. By increasing the sweep velocity it is possible to observe individual rf cycles in the lower hf communications range. A physical display of the rf signal aids the elimination

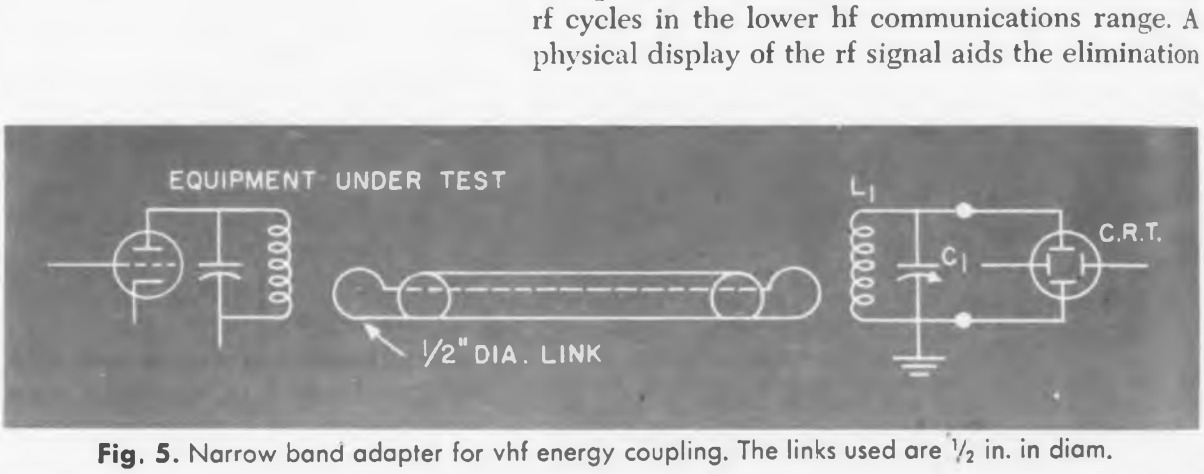


Fig. 5. Narrow band adapter for vhf energy coupling. The links used are ½ in. in diam.

$$f \text{ resonance} = \text{(a)} \quad \frac{1}{2\pi\sqrt{L_1(C_1 + C_2)}} \qquad \text{(b)} \quad \frac{1}{2\pi\sqrt{\frac{L_2C_1C_2}{C_1 + C_2}}}$$

Fig. 6. Analysis of the all-band tuner. (a) shows the low frequency case where L_2 is effectively non-existent, while in (b) L_1 becomes virtually open. Equations for the resonant frequencies of the two cases are given for $L_1 >> L_2$.

Fig. 4. Photographs of oscilloscope displays using the Q-Probe. (a) shows an unmodulated carrier free from parasitics, power supply ripple or harmonic content. In (b) the output from a mobile transmitter shows traces of vibrator power supply hash. (c) represents a double sideband suppressed carrier, modulated at 1000 cps, with a heavily speech-clipped audio signal. Note the well-rounded corners which indicate proper functioning of the low-pass filter following a speech-clipper stage. In (d) the output from an a-m final amplifier is overloading the modulator due to improper tank tuning and loading.

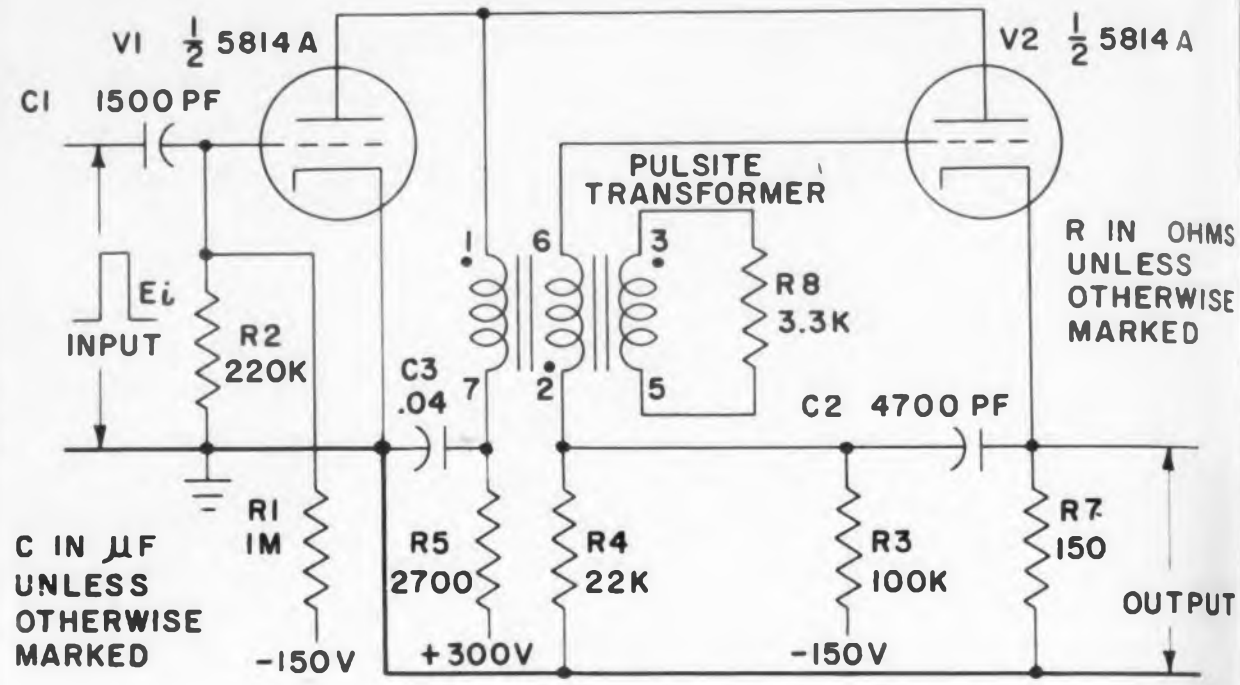
of such pernicious problems as parasitic squegging in a tetrode final amplifier. The effects of parasitic suppressors can be observed as soon as they are placed in the offending circuit.

For rf displays at frequencies above 50 mc the simple Q-Probe circuit approach breaks down due to multiple and spurious resonances within the loop and cable assembly. Relatively narrow-band adapters can be made for use up to several hundred megacycles by employing a link-coupled transmission line between the resonant circuit and the source of signal. This is shown in the circuit of Fig. 5. A major difficulty limiting the application of this rf waveform display system is the cross-coupling between horizontal and vertical deflection plates of the crt and external wiring. This coupling introduces rf into the horizontal tune base and results in distorted patterns; generally the displays become tilted and may have reverse sweep portions, making the display unusable.

Appendix

The operation of the all-band tuner utilized by the Q-probe can be analyzed by considering two functional schematics corresponding to the extreme low and high frequency settings of C_1 and C_2. These are shown in Fig. 6. Note that at low frequency I_2 is effectively a short circuit due to its low inductance. C_1 and C_2 are therefore in parallel. These summed capacitances resonate with large coil L_1. At high frequency L_1 is a very high impedance and signals are injected into the circuit primarily via shunt capacity C_s. C_1 and C_2 are in series, providing the necessary low minimum capacity to extend the upper frequency limit of the tuner. This series combination together with the load capacity tune with L_2. Intermediate settings of C_1 and C_2 and a judicious choice of L_1 and L_2 produce continuous spectrum coverage.

Blocking Oscillator Transformers



Parallel-Triggered Blocking Oscillator (NBS Preferred Circuit No. 46). Depending on transformer used, output amplitude across 150 ohm cathode resistor lies between 85 and 60 v peak-to-peak for pulse durations of 0.1 to 10 µsec respectively. Pulse width and amplitude may be changed by varying component values. For example, to obtain maximum pulse width with a particular transformer, resistance is added in series with the primary. This reduces the average plate current with a proportionate loss in pulse amplitude. Component tolerances are 10 per cent for resistors and 20 per cent for capacitors.

Modular

KIT-TYPE circuit assemblies, closely adhering to the National Bureau of Standards "Preferred Circuits" design are now available. Twenty-three single tube modular circuits, each one assembled on an etched card, are provided in a kit which includes a storage case, breadboard, power distribution unit, connector cords, blank circuit cards and the NBS "Preferred Circuits Handbook."

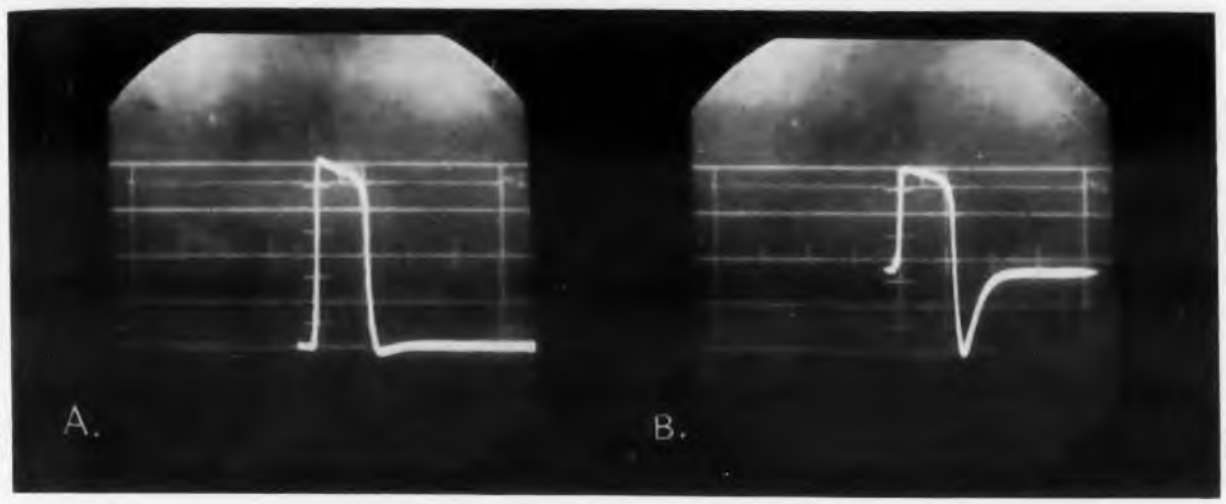
The Dynamod Kit, manufactured by Dale Boison Co., 2928 Nebraska Av., Santa Monica, Calif., includes almost all of the circuits in the NBS handbook. The modules are particularly convenient for breadboard design and block circuitry. A wide variety of pulse, control, radar, and video circuits can be breadboarded in a matter of minutes.

The modules feature quick installation and removal from a breadboard chassis by means of snap-on connectors. Interconnection between modules, power supplies, adjacent circuitry, or test instruments can be established quickly without solder or tools. Easy access to components and simple solder connections allow the user to make quick modifications to meet individual requirements. Such changes do not damage the modules which may be used indefinitely. For further information turn to the Reader's Service Card and circle 21.

A SERIES of miniature plug-in pulse transformers has been developed for operation in NBS "preferred" blocking oscillator circuits. Nominal pulse widths from 0.1 to 10 usec are provided by eight transformers whose characteristics suit them to most requirements for blocking oscillators.

The series of blocking oscillator transformers and two interstage transformers were developed by the Airpax Products Co., Transformer Div., Baltimore 20, Md. Their construction results in high primary inductance thereby giving good low-frequency response. Yet there are relatively few primary turns so that the distributed capacitance is small, making for good high-frequency response. The self-shielding magnetic circuit results in exceptionally small units and low leakage inductance. High permeability ferrite cores are used to minimize magnetizing current and thereby reduce back swing. Characteristics are stable with temperature. The case can be grounded so that performance in critical circuits is less disturbed by other components near the transformer.

Hermetically sealed and insulated to withstand 500 vdc hipot, these transformers meet requirements for MIL-T-27A, Grade 1, Class R. They operate from −50 C to +105 C with a maximum average power rating of 2 w. Their maximum duty cycle is 0.05. Insulation resistance from all windings exceeds 10,000 megohms. For further information turn to the Reader's Service Card and circle 22.



Blocking oscillator pulse with 0.52 μsec duration. A. Pulse at cathode has amplitude of 74 v peak-to-peak. B. Pulse at grid has amplitude of 330 v peak-to-peak.

Preferred Circuits

Modular Preferred Circuits useful for breadboard design and block circuitry.

Design of Mixers Using C

K. A. Pullen, Jr.

Ballistic Research Laboratories
Aberdeen Proving Ground, Md

EXCEPT for the noise which results from imperfections in current division in a mixer—due to the finite charge of the electron—the use of the reference voltage as the larger of the pair of mixed voltages gives the mixer a linear time-variant characteristic which makes possible the use of the theorem of superposition in the design process.

Diode Mixer Design

The variation of conductance with the reference signal is used to produce mixing with diodes, and the tubes. When the reference signal is sufficiently large, variation of amplification with time for triodes. When the reference signal is sufficiently large, the diode conductance switches between two values, zero (approximately) and a value of about 1 to 10,000 μmhos. Then the conversion gain for the diode is:

$$K_c = \frac{1}{2}\{(g_f R_L/[1 + g_f R_L]) - (g_r R_L/[1 + g_r R_L])\} \quad (1)$$

With triodes and multigrid tubes used as mixers, the amplification varies uniformly as the reference signal voltage is changed. In this case, the conversion amplification is:

$$K_c = \frac{1}{4}(K_p - K_n) \quad (2)$$

The design of mixers is based on these two equations in addition to conventional amplifier design techniques. As an example, consider a diode to be used as a mixer. Its forward conductance is 0.01 mhos, its reverse 10^{-8} mhos. The problem is to select the proper terminating impedance, and determine the conversion gain in the diode circuit.

The proper terminating impedance for use with a diode control circuit should be the square root of the product of the forward and back impedances, or 10^{-5} mhos for this diode (100,000 ohms). Consequently, the forward gain is approximately unity, the reverse zero, giving a conversion gain of 0.5.

If the reference signal is sufficiently small, so that the product $g_f R_L$ varies approximately linearly, then the coefficient should be a quarter instead of a half.

Triode Mixer Design

Since the triode mixer is the simplest form of mixer in which a conversion gain greater than one half may be obtained, it is especially useful—first because of the

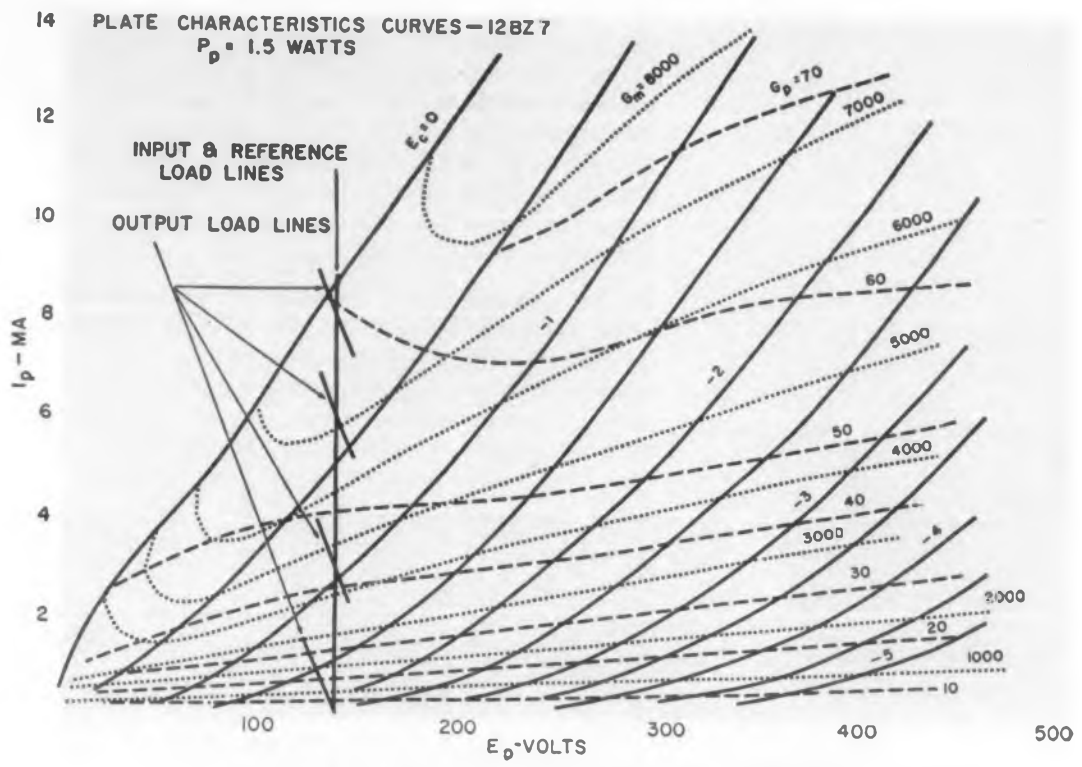


Fig. 1. 12BZ7 triode plate characteristic curves

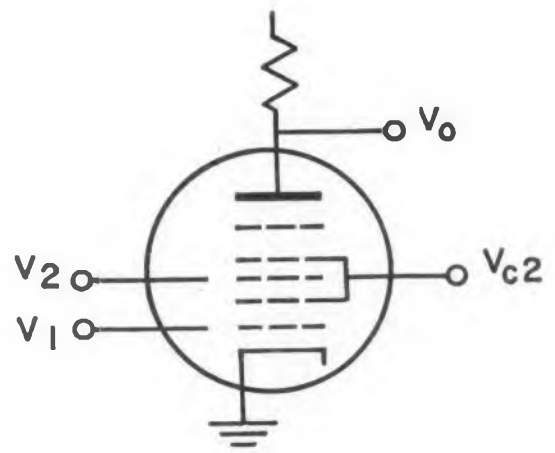


Fig. 2. 6BE6 pentagrid converter

Conductance Curves

increased gain, and second because of the lower noise contribution compared to multigrid tubes. The triode should be used over the frequency range at which a conversion gain greater than a half can be obtained, and the diode at higher frequencies.

The design of the triode mixer, Fig. 1, parallels the design of either the triode RC amplifier in the case where the output load is resistive, or the triode impedance-coupled amplifier when the output load is reactive. The most important difference is that the load circuit, for best design, should always offer a very low impedance to the input frequencies, and a sizeable impedance to the output frequency. The fact that the output impedance at the input frequencies is very small means that the output voltage, including the signal, is small.

The triode mixer has a set of load lines instead of only one or two. At the two input frequencies—that is to say the signal and the reference frequencies—the load line is a vertical line at the supply voltage (or static plate voltage with RC mixers). The output load lines are symmetrical about the input load line, and have a slope corresponding to the output resistance or impedance. The approximate conversion gain for this circuit is given by the equation:

$$K_c = \frac{1}{4}\left[-g_m Z_L/(1+g_p R_L)\right] p - \frac{1}{4}\left[-g_m R_L/(1+g_p R_L)\right] n \quad (3)$$

where p means that the expression is evaluated at the positive limit of the reference voltage swing, and n the negative limit.

Consider a *12BZ7* tube used as a mixer, with $V_{bb} =$ 140 v, R_L at the i-f frequency = 10,000 ohms, and zero at the two input frequencies. If the local oscillator signal is 2.5 v peak-to-peak, and the rectification bias is used, the conversion amplification may be computed as follows:

Given	Read from g-Curve	Equations	Solutions
12BZ7 tube	$g_{mp} = 7500$	Eq. (3)	$K_c = 11.2$
$V_{bb} = 140$ v	$g_{pp} = 60$		
$V_{cm} = 2.5$ v	$g_{mn} = 300$		
$Z_1 = 10{,}000\ \Omega$	$g_{pn} = 6$		

As can be seen, the equivalent conversion transconductance is 1100 μmhos.

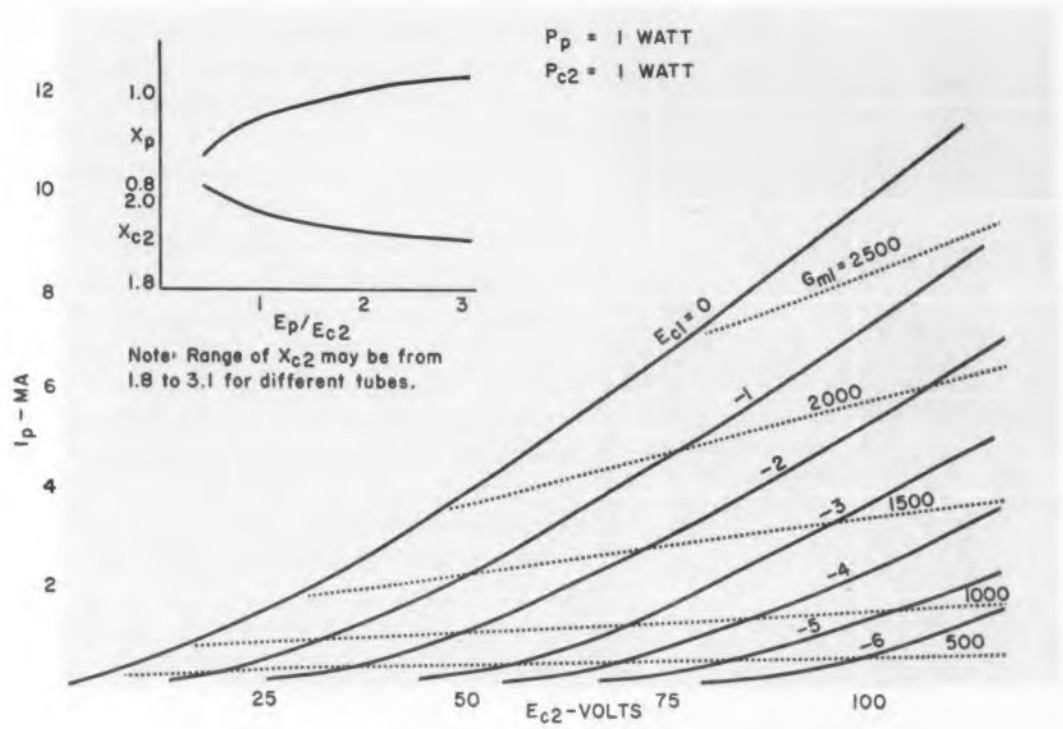


Fig. 3. 6BE6 screen characteristic curves

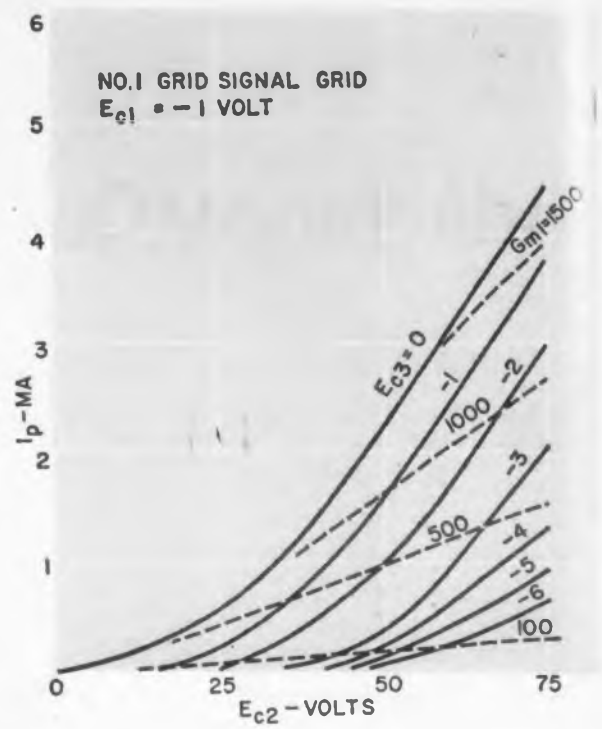


Fig. 4. 6BE6 screen converte

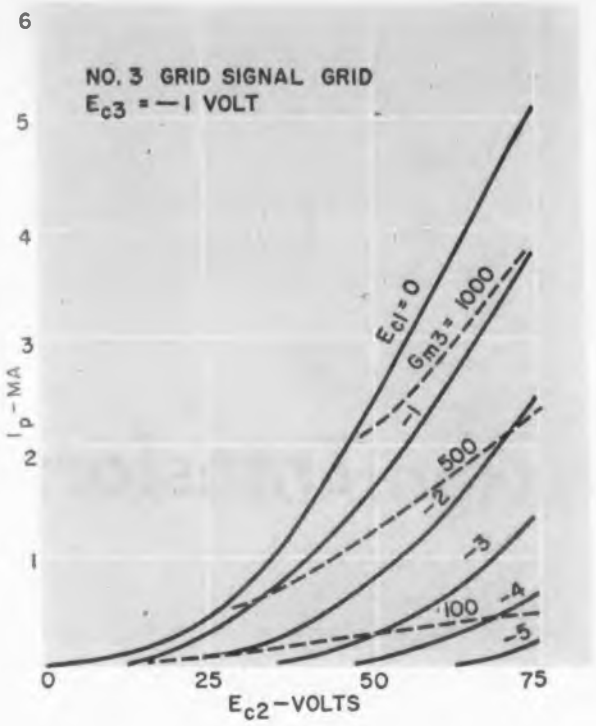
Multigrid Mixer Design

The sole purpose for the development of multigrid mixers, Fig. 2, was to improve isolation of the local oscillator signal from the incoming signal to reduce frequency pulling. The design of mixers using multigrid tubes requires a combination of pentode design techniques and special mixer *g*-curves.

The first step in the design of a mixer is the design of a straight pentode amplifier using the screen characteristic curves for the tube. Only two precautions should be noted in this design—the first is that the average screen current may be actually higher than is calculated on the basis of the *g*-curve, and the second is that as a result additional dissipation margin is required. Fig. 3 shows screen characteristics for the *6BE6* tube.

Since two grids are available for application of input signals in the multigrid mixer, a choice is available to the designer. Examination of the converter *g*-curves of the *6BE6* tube, Fig. 4, shows that the highest over-all range of transconductance is available by applying the incoming signal on the first grid, the reference signal on the third grid. The manufacturer recommends application of the reference signal on the first grid, with the incoming signal on the third grid, presumably to permit the first grid and cathode to be part of an oscillator circuit.

Regardless of the arrangement of the signal voltages, the adjustment of the mixer to provide conversion is the same. The half of the converter *g*-curve which corresponds to the selected signal arrangement is chosen (transconductance on the input signal grid must be known in terms of the voltage on the reference oscillator grid), and the amplitude of reference signal required to shift the transconductance on the



characteristic curves

input grid from maximum value to approximately zero is read at the selected screen voltage. The conversion gain then is

$$K_c = (G_{mp} X_{pp} R_L - G_{mn} X_{pn} R_L)/4 \qquad (4)$$

where the nominal transconductances are the values for the input signal grid corresponding to the positive and negative limits of the bias on the reference oscillator grid.

If a *6BE6* tube is used as a converter tube with $V_{c2} = 50$ v, and a separate local oscillator for the reference voltage, the peak-to-peak reference signal required to provide cut-off on the grids can be calculated. Determine the conversion transconductance for both the first and the third grids, using the other for the reference signal in each case. Take the X_p factors as unity.

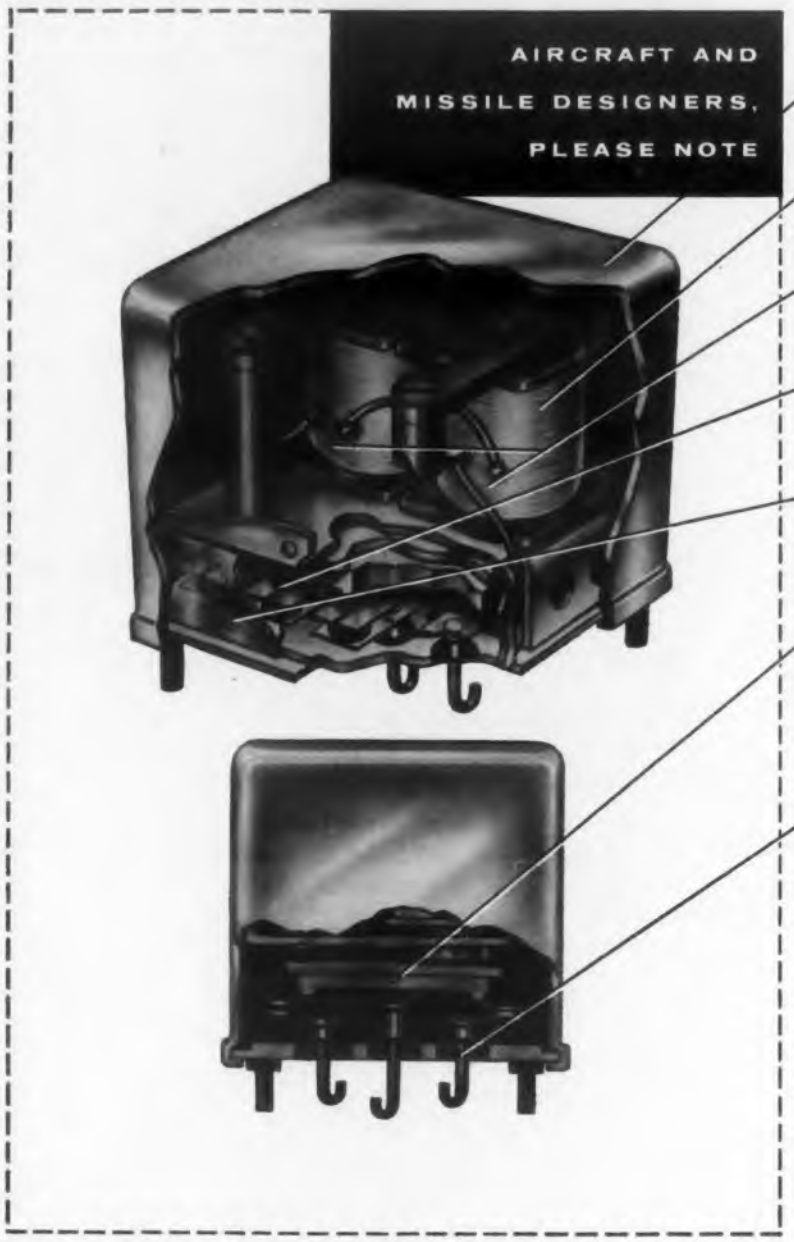
Given	Read from g-Curve	Equations Solutions
6BE6 tube	$V_{c3p} = 0$, $V_{c3n} = -4$ v	Eq. (4) $g_{c1} = 300$
$V_{c2} = 50$ v	$V_{c1p} = 0$, $V_{c1n} = -6$ v	$g_{c3} = 250$
$V_{bb} = 100$ v	$G_{m1p} = 1000$, $G_{m1n} = 0$	
	$G_{m3p} = 1200$, $G_{m3n} = 0$	

Dissipation Problems

The dissipation of both the screen and the plate of the mixer tube should be calculated both with normal reference signal applied and also without the reference signal, since the power dissipations required of mixers often are reasonably close to rated values. The mixer should be so designed that the rated values are not exceeded even with the reference voltage removed. This usually means the use of lower than normal screen voltages.

Get unprecedented performance—

See for yourself why the new LEACH BALANCED-ARMATURE RELAYS outperform all other types in resistance to shock, acceleration and vibration



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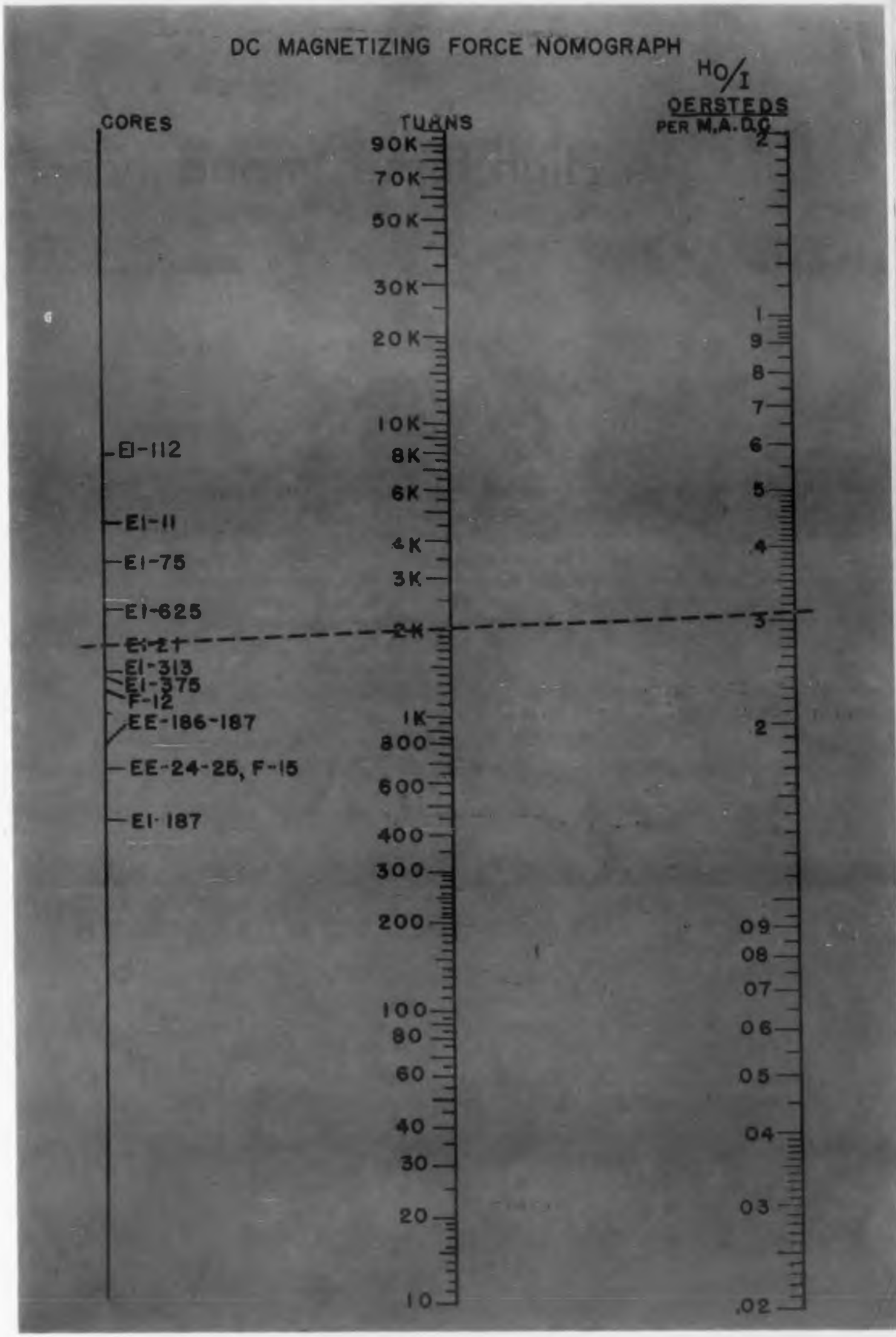
Transforme

ne Design Nomograph—III

THIRD in the series of transformer design nomographs is this one for determining the dc magnetizing force, number of turns, or type core—given the two other parameters. This nomograph is intended for use in designing small audio transformers and filter inductances. The core reference numbers given are those of Allegheny-Ludlum. A stacking factor of 0.9 is assumed.

Example of Use

An output transformer wound on an EI-21 core has a primary of 2000 turns. What will the magnetizing force (H_0) be for a dc current of 20 ma? Laying a straight edge from *EI-21* on the *"Cores"* scale through *2000* on the *"Turns"* scale gives an H_0/I of 0.31 oersteds per milliampere. Since the current is to be 20 ma, $H_0 = 20 \times 0.31 = 6.2$ oersted.



A High Input Impedance Transistor Circuit

Philip J. Anzalone

Radio Corp. of America,
Camden, N. J.

THE LOW input impedance of transistor circuits presents a serious disadvantage in some circuit applications. This article describes a design method for increasing the obtainable input impedance orders of magnitude beyond that observed for conventional transistor circuits. The boot-strapped collector emitter follower circuit is in effect a unity gain amplifier with an input impedance of up to 1000 megohms. Such a circuit has been used to advantage by the author in a transistorized high voltage push-pull sweep generator. It could also prove useful in the design of a transistorized vacuum tube voltmeter or similar circuits.

Emitter Follower Circuit

High input impedance in transistor circuits is normally obtained by the use of single or cascaded emitter follower stages. However, there is a limit to the input impedance which can be obtained by these methods due to the loading effect of the grounded collector.

The emitter follower circuit is shown in Fig. 1, along with the expression for the input impedance. This expression neglects R_e and R_b because these are negligible when R_L is large, which is the case to be considered. The equation is actually an expression for two resistors in parallel, R_c and βR_L, and the input current does break down into two paths. One part of the input current flows to the collector, and this is the loading effect due to the collector (R_c); the other part flows to the emitter and is the loading effect due to the emitter (βR_L).

When R_L is much smaller then R_d, the expression for the input impedance is $R_{in} = \beta R_L$. When $R_L = R_d$, the loading effect of the emitter and collector are exactly

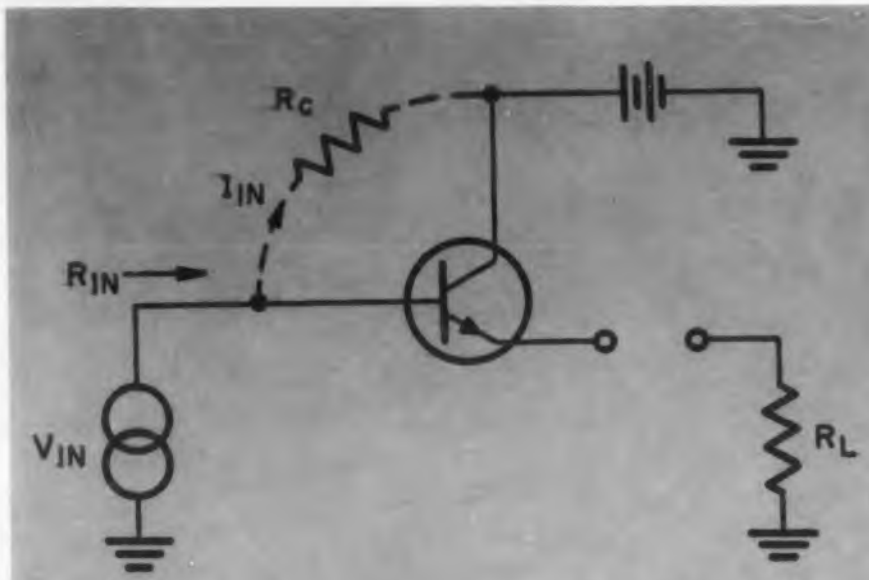


Fig. 1: Emitter follower circuit with high input impedance, and expression for the input impedance.

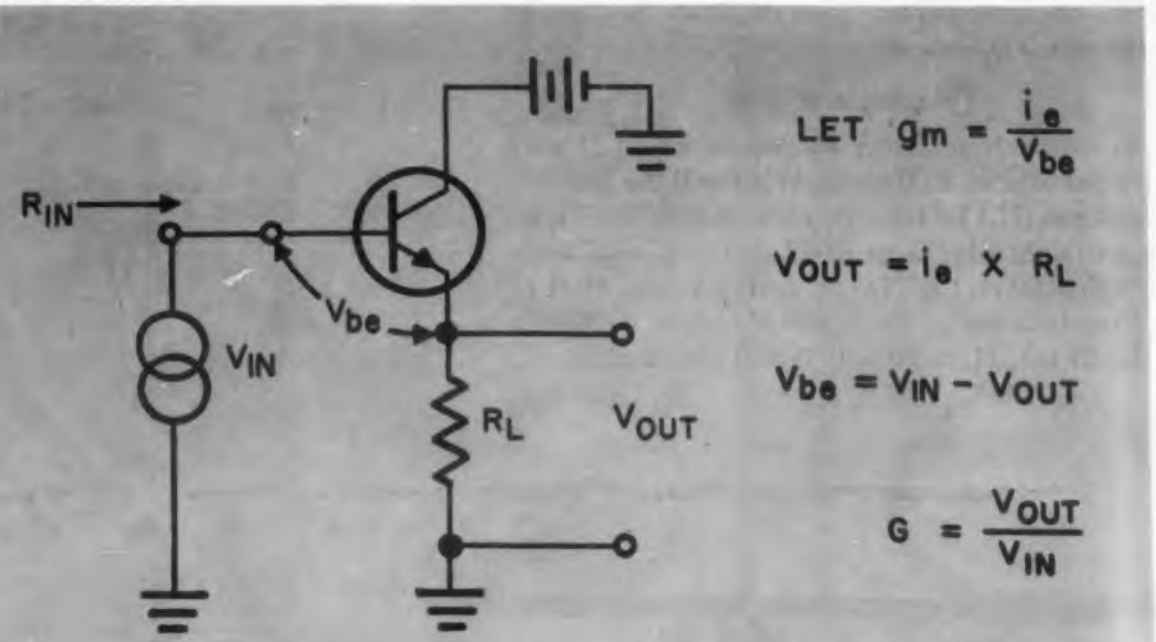


Fig. 2: Emitter follower circuit with its four basic equations. The gain of this circuit is very close to unity.

equal, because $R_c = \beta R_d$. When R_L is much greater than R_d, the loading effect of the emitter is negligible, all of the loading effect is due to the collector, and the input impedance reduces to $R_{in} = R_c$.

This indicates that the maximum input impedance that can be obtained with the grounded collector emitter is R_c no matter how many emitter followers are cascaded. This result is also obtained by calculating the loading effect of the collector with the emitter open circuited (neglecting the emitter loading effect):

$$R_{in} = \frac{V_{in}}{I_{in}} = \frac{V_{in}}{V_{in}/R_c} = R_c$$

The reason for performing this simple calculation will be apparent when we consider the bootstrapped collector emitter follower (Fig. 4).

Another characteristic of the emitter follower circuit which is of concern is its gain. Fig. 2 shows the emitter follower circuit with four equations which are basic to it represented in the figure. From these equations it is easy to derive the expression for gain as $G = 1/G_m R_L + 1$. When $G_m R_L$ is large, the fraction $1/G_m R_L$ is very small and the gain of the emitter follower becomes close to unity.

To illustrate how close to unity the gain normally is, an example is shown in Fig. 2. The G_m of a transistor is taken as 0.05 mhos. Since the G_m of a 953 transistor is about one-tenth of a mho, and the G_m of a *2N156* germanium power transistor is about 2 mhos, a value of 0.05 mhos is not unrealistic. If R_L is 20,000 ohms, the product of $G_m R_L$ is equal to 1000, and the gain of the circuit is 0.999. The gain of a transistor emitter follower is easily ten times closer to unity than its equivalent vacuum tube circuit, the cathode follower. This is due to the fact that the G_m of a transistor is at least 10 times the G_m of a vacuum tube.

Bootstrapped Collector Emitter Follower

A variation of the emitter follower circuit called "a bootstrapped collector emitter follower," provides us with a circuit having a very high input impedance. Fig. 3 is the basic circuit. In this circuit, the collector supply of the first emitter follower is formed by returning the low side of the power supply battery to the output. This places the output voltage on the first collector instead of having the first collector grounded. The loading effect of the collector can then be calculated as follows: $R_{in} = V_{in}/I_{in}$. Neglecting emitter loading effect, that is, with the emitter open,

$$R_{in} = \frac{V_{in}}{\frac{V_{in} - V_o}{R_c}} = \frac{V_{in} R_c}{V_{in} - G V_{in}} = \frac{1}{1-G} R_c$$

This expression is the maximum input impedance that can be obtained with the bootstrapped collector

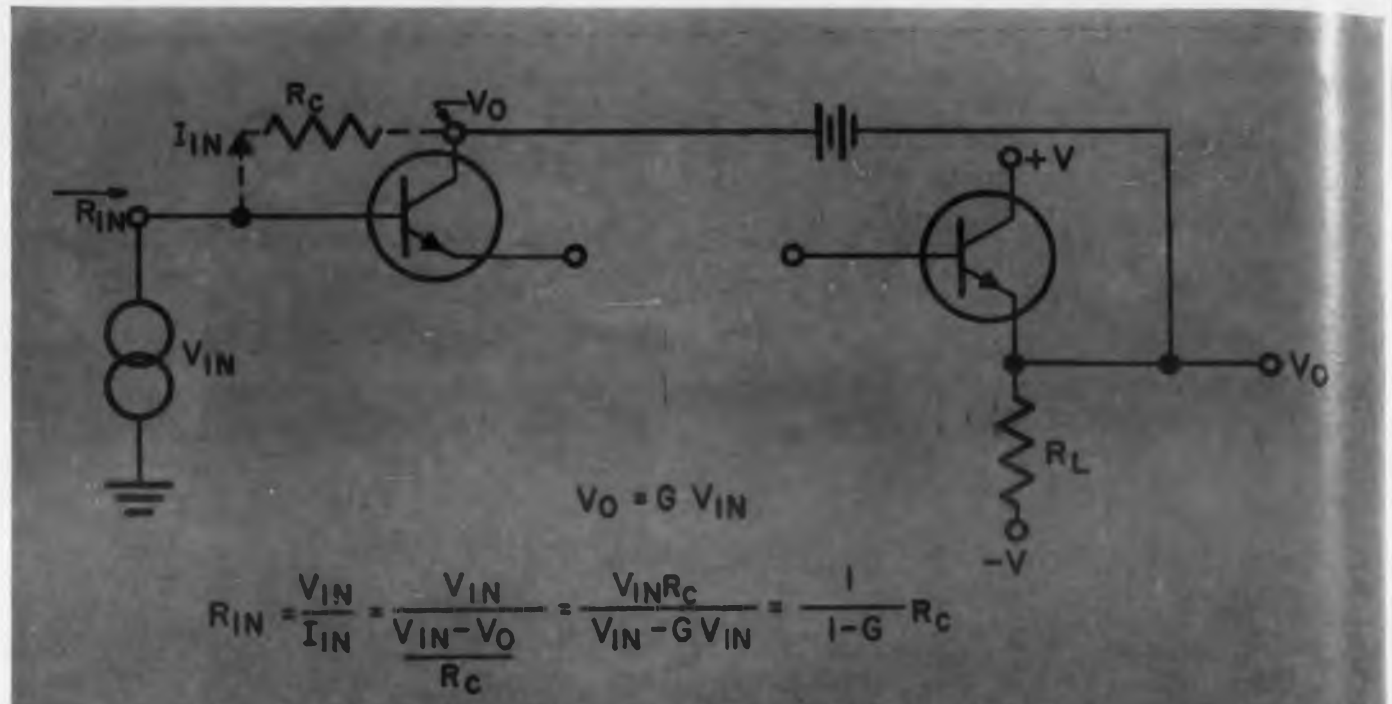


Fig. 3: Basic circuit of a bootstrapped collector emitter follower. The input impedance of this circuit is about 100 megohms.

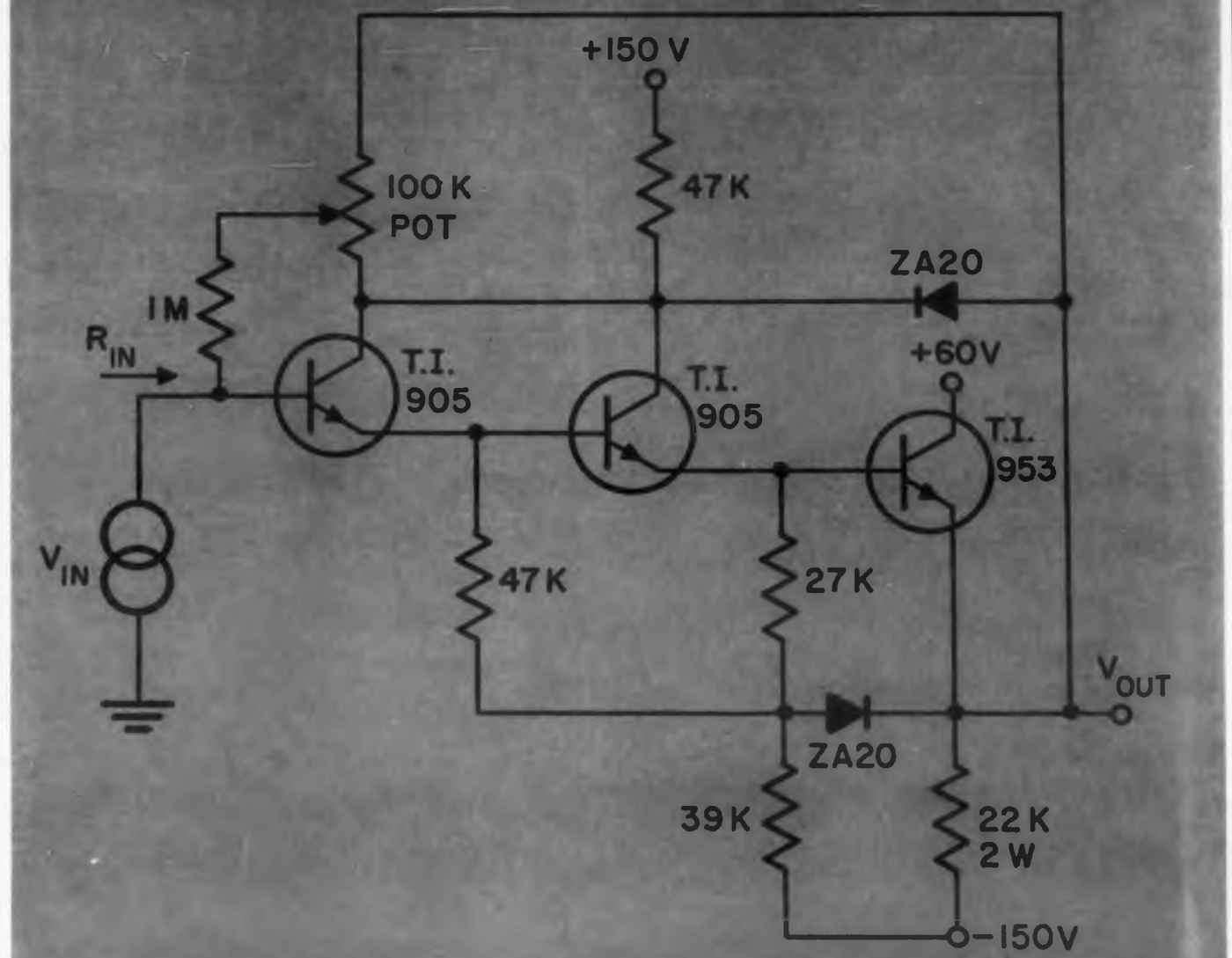


Fig. 4: A more practical circuit of the bootstrapped collector emitter follower. The diodes eliminate the necessity of floating power supplies.

emitter follower. Recalling that the gain equals 0.999 for R_L equal to 20,000 ohms, and $G_m = 0.05$ mhos, the maximum value of R_{in} becomes 1000 times higher than with the old grounded collector circuit, because

$$R_{in} = \frac{1}{1-0.999} R_c \simeq 1000 \times R_c$$

A more practical version of the bootstrapped collector emitter follower, without a floating power supply, is shown in Fig. 4. The ZA20 Zener diodes eliminate the necessity of floating power supplies. Two Zener diodes are used so that the negative supplies of the first two emitter followers are bootstrapped as well as the collectors. This eliminates the emitter loading effect of the 47 K emitter resistor of the first stage and the 27 K emitter resistor of the second stage. The 1000 K potentiometer-1 megohm resistor is a biasing arrangement, to provide the proper amount of base current to the first stage. The potentiometer can be adjusted until the input current required by the circuit is zero.

The input impedance that this circuit would provide is about 100 megohms. In addition to eliminating the loading effect of R_c, the bootstrapped collector emitter follower also eliminates the loading effect of collector to base capacity for better high frequency response. The circuit is d-c coupled and its frequency response also goes down to d-c.

If the circuit is to be used for d-c amplification, a few words on drift are appropriate. Since the base current of the first stage is approximately 20 μa, the temperature drift will be a percentage of 20 μa. The most obvious way to reduce current drift, referred to the input, would be to reduce the required base current from 20 μa down to say 1μa. In the case of silicon transistors, we may neglect I_{co}. The base current could vary by a much larger percentage in the 1 μa case than in the 20 μa case and still provide much less current drift referred to the input. This simple technique for reducing drift is known as "starving the first stage." The disadvantage of doing this is rather obvious. The β of the starved stage falls down to some ridiculously low value like 2 or 3. This necessitates including at least one extra transistor, more than is actually required for the desired impedance transformation. Even with presently available transistors, however, the drift and input impedance of a vacuum tube grid can be approached.

The voltage swing capability of this circuit is limited only by the last stage. In this case, a 120 v transistor is used and consequently, 110 v swing can be obtained. Boot-strapping the first two emitter followers also allows the use of transistors with as low a breakdown voltage as desired in these stages. Consequently, low voltage transistors having high betas can be used for a greater impedance transformation. Noise and I_{co} leakage current of the first two stages is reduced because of the lower collector to base voltage required by the boot-strapped collector emitter follower.

Developments in Printed Antenna Design

J. A. McDonough, R. G. Malech, and J. Kowalsky,
Airborne Instruments Lab., Inc.
Mineola, New York

END-FIRE and broadside arrays practical for use at microwave frequencies are made possible using the etching techniques employed in the construction of printed circuits. Of significant practical importance in the construction of antennas for operation in the S-band, the etching technique has been applied successfully to antennas operating in the X-band. The most obvious application for these concepts is in flush-mounted aircraft antennas and low cost light weight arrays.

Capacitively Coupled Collinear Array

A recently developed broadside array is shown in Fig. 1. This array consists of a series of collinear electrical half-wave elements, separated by capacitive gaps. This radiating structure has the strip elements bonded to or printed on a dielectric sheet that in turn is supported—in this case—by a low-dielectric-constant foam over a ground plane. The radiating strips are energized by a center feed consisting of a parallel two-wire balanced transmission line and a balanced-to-unbalanced transformer.

By physically adjusting the coupling between the elements and adjusting the length of the elements, a phase reversal can be obtained in the voltage distribution along the antenna at each gap, as shown in Fig. 2. A 180 deg phase reversal at each gap makes each element act as a half-wave radiator with a current distribution that is in phase with that of the other elements. The array then has a broadside radiation pattern.

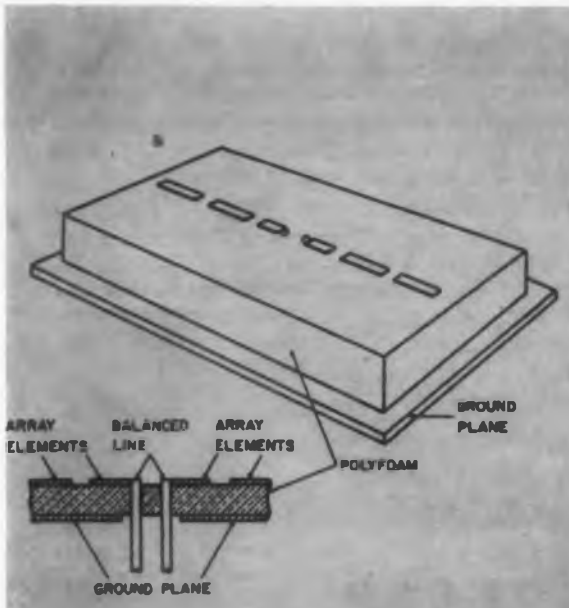


Fig. 1. Five-element capacitively coupled collinear stripline array.

Fig. 2. Voltage distribution for a five-element capacitively coupled collinear stripline array.

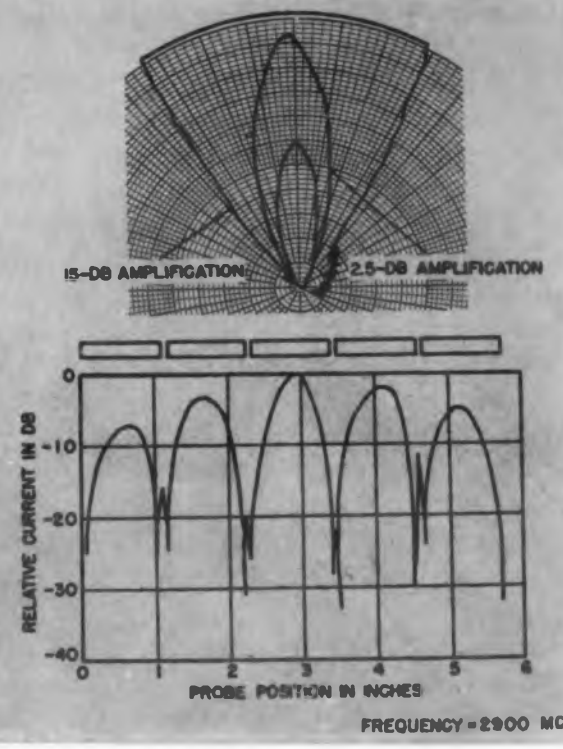


Fig. 3. E-plane radiation pattern and current distribution for a five-element capacitively coupled stripline array.

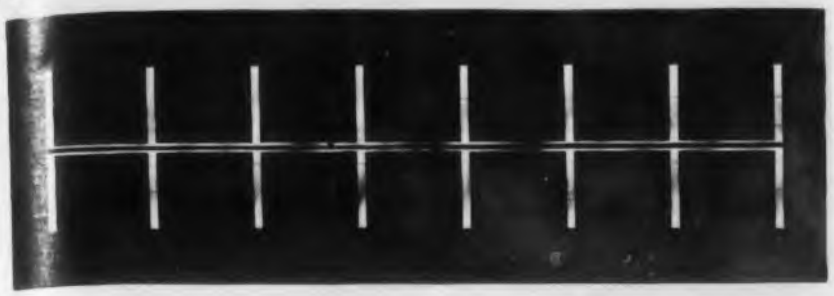


Fig. 4. Forty-element capacitively coupled collinear array.

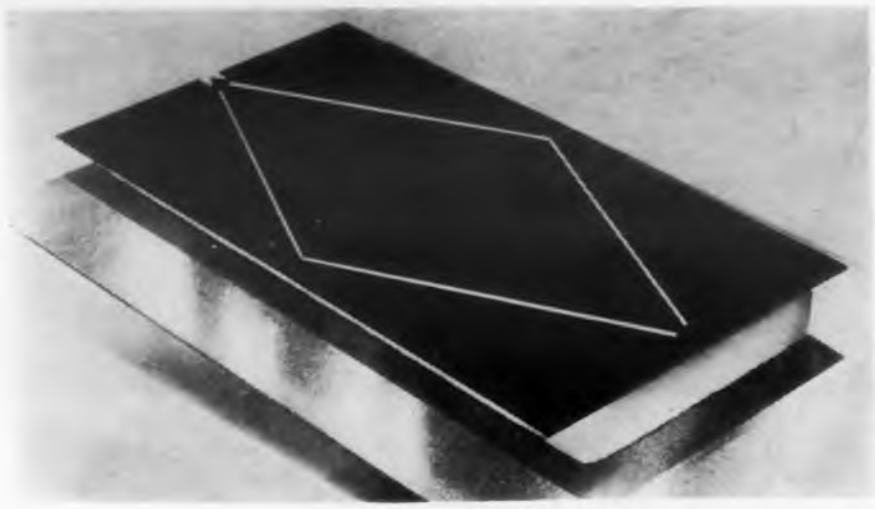


Fig. 5. Printed rhombic antenna. Note mounting above ground plane on epoxy foam.

To improve the pattern of radiation, the illumination of the elements along the array was tapered. This was done by probing the array with a current loop and adjusting the size of the capacitive gaps to provide the desired coupling. Fig. 3 shows the relative magnitude of the current distribution along a typical array at 2900 mc and the E-plane radiation pattern that was obtained. The current peaks at the capacitive gaps indicate that a phase reversal is obtained across the gaps. When the array was adjusted so that a peak did not occur across a gap, serious radiation-pattern deterioration resulted.

As an illustration of the design of a large printed broadside array, Fig. 4 shows a 40-element capacitively coupled array for operation in the S-band. The array is 21-1/4 in. by 4-5/8 in. and is printed on epoxy bonded Fiberglas FF-91, which is 1/16 in. thick. Each column of collinear elements is fed in phase from the two-wire transmission line. The array is spaced 3/4 in. over a ground plane. The physical length of each element is close to 1/4 wavelength although electrically each is a half-wavelength. Radiation pattern results obtained from this array are summarized in Table 1.

Printed Rhombic Antennas

The standard design formulas for rhombic antennas are directly applicable to their printed counterparts and the beamwidths, beam pointing, and side lobes are essentially the same as those obtained from regular rhombic antennas. The only compensation necessary is to change the length of the elements to compensate for the slower propagation velocity due to the dielectric sheet on which the rhombic was printed.

In a typical configuration of end-fire array design, the rhombic antenna shown in Fig. 5 was printed on a sheet of Teflon glass and mounted above a ground plane. It was energized at the left end with a two-wire feed; a resistance-card load was placed at the right end. Each leg of this rhombic antenna was approximately 7 in. long, and it was tested for operation in the S-band.

Printed rhombic antennas may be arrayed from end to end. Instead of a load, a second rhombic antenna is connected to the first, and the load is placed at the end of the second rhombic antenna. Fig. 6 shows the result of tests made on these arrayed rhombic antennas. Examination of the table indicates that this type of arraying probably should not include more than two rhombic antennas since the azimuth plane-half-power beamwidth is essentially the same for the two-element and three-element arrays.

Two coplanar rhombics are shown in Fig. 7. The outer rhombic antenna is energized but the inner rhombic antenna is a parasitic element having an adjustable length of shorted two-wire transmission line attached to the conventional feed point. In the construction and testing of this antenna, it was believed that improved characteristics could be obtained if the current distribution along the rhombic elements could be controlled or modified. By moving the adjustable short, some modification was obtained. The elevation pointing of the beam was changed from 23 to 26 deg, and the elevation-plane

FREQUENCY (MC)	HALF-POWER BEAMWIDTH (DEGREES)	SIDE-LOBE LEVEL (DB)
2500	50	−15 *
2550	—	—
2600	48	−15 *
2650	—	—
2700	46	−15 *
	E-PLANE	E-PLANE

* SMALLER THAN

DIMENSIONS OF ARRAY:
ELEMENT LENGTH: 0.906 INCH
GAP SPACING: 0.016 INCH
ELEMENT WIDTH: 0.228 INCH
SPACING ABOVE GROUND PLANE: 3/4 INCH
SPACING BETWEEN COLUMNS: 3.0 INCHES

Table 1. Radiation characteristics of capacitively coupled collinear stripline array.

PERFORMANCE OF 16-WAVELENGTH LADDER ANTENNA (DIPOLE SPACED 1 INCH FROM FIRST ELEMENT)

FREQUENCY (MC)	HALF-POWER BEAMWIDTH (DEGREES)	SIDE-LOBE LEVEL (DB)	INPUT SWR
2000	23	8	2.3
2100	22	10	3.0
2200	18	10.5	3.9
2300	19	11.5	2.2
2400	18	14	1.7
2500	19	15.5	1.8
2600	18	16	2.3
2700	17	21	2.3
2800	18	22.5	1.8
2900	18	19	2.2
2950	19	15	2.6
	E-PLANE	E-PLANE	

Table 2. Performance of sixteen-wavelength antenno.

half power beamwidth was changed from 24 to 22 deg. The side-lobe level could be varied about 2 db. Possibly a greater variation could be obtained by printing a second parasitic rhombic antenna outside the energized rhombic antenna or by energizing more than one at a time.

Yagi Antennas

As in the case of rhombic antennas, practically any existing Yagi design can be scaled to the proper frequency, and then by shortening the elements and the spacings by a factor corresponding to the slower velocity of propagation along the dielectric sheet, a radiation pattern and results can be obtained that are essentially the same as those obtained from the original Yagi design. The velocity factor for Teflon glass GB-112T laminate, 0.020 in. thick, is about 0.9 at S-band. The feeding dipole element or even a folded dipole on the same dielectric sheet that contains the parasitic elements can be printed.

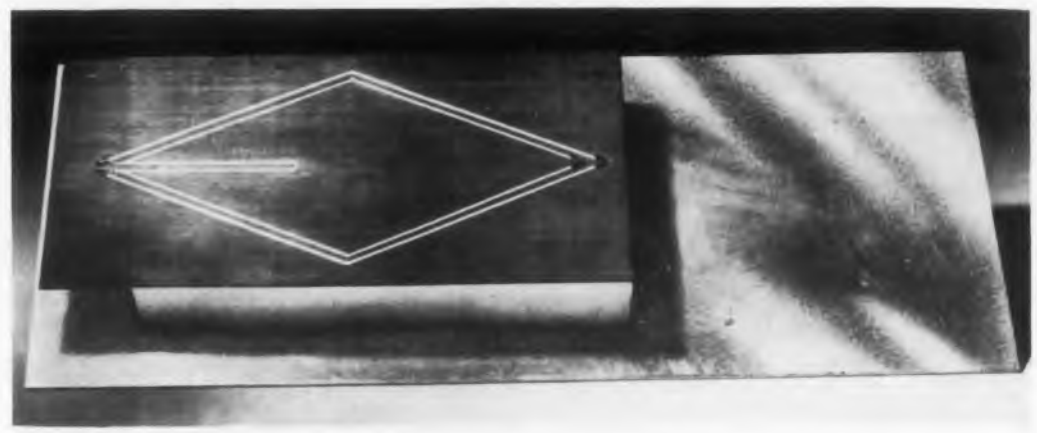


Fig. 7. Coplanar rhombic antenna. The inner rhombic is a parasitic element: the feed point is not energized but consists of an adjustable length of shorted transmission line. Changing the length of this line modifies the current distribution along the rhombic elements and permits "tuning" for optimum propagation characteristics.

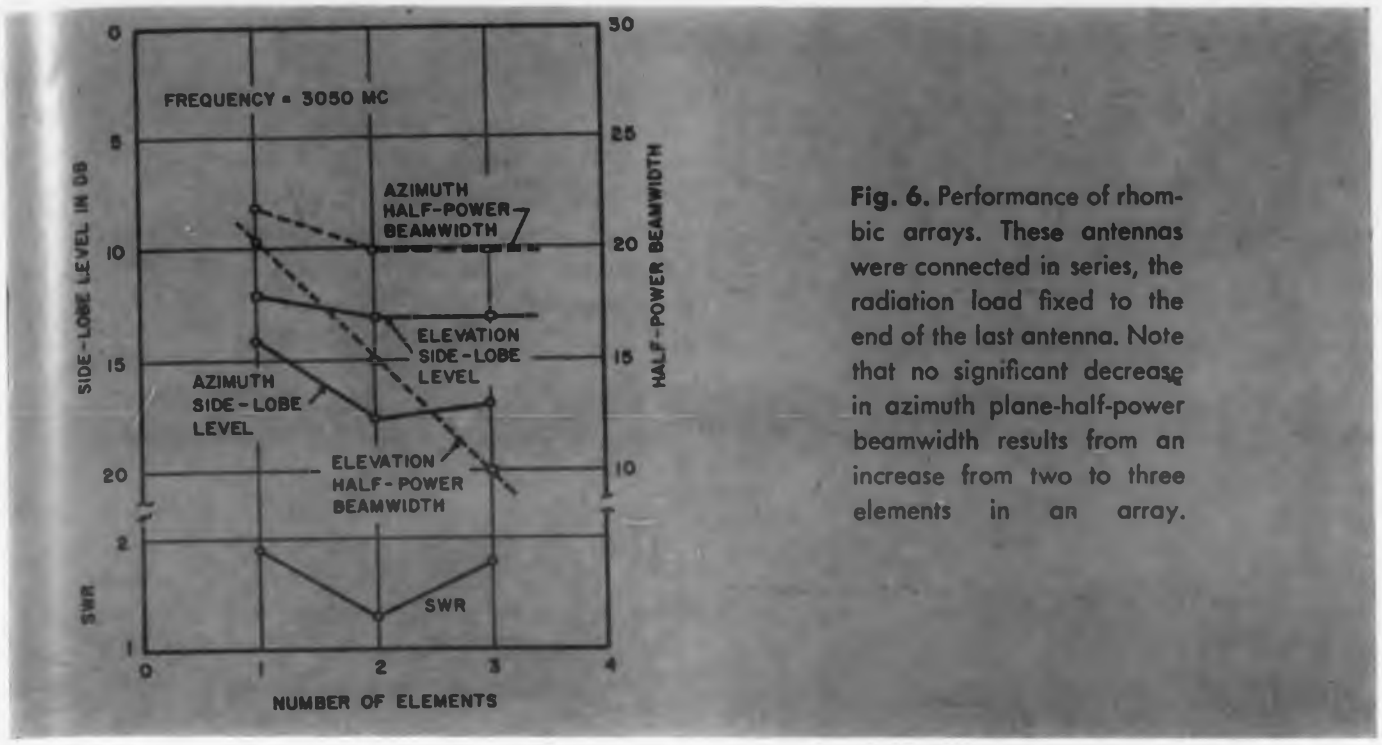


Fig. 6. Performance of rhombic arrays. These antennas were connected in series, the radiation load fixed to the end of the last antenna. Note that no significant decrease in azimuth plane-half-power beamwidth results from an increase from two to three elements in an array.

Ladder Antenna

By a periodic variation or modulation of the characteristics of a surface wave transmission line, it is possible to construct end-fire antennas that are many wavelengths long and that have higher gain than the usual upper limit of about 16 db obtained with conventional Yagi, rhombic, and dielectric-rod antennas. Since surface-wave antennas consist essentially of a transmission line with a phase velocity less than the velocity of light, if the characteristics of this line are varied there is a transfer of energy from the surface-wave mode to the radiation mode. In the top of Fig. 8, a Simon-Weill antenna—a metal rod loaded with metal disks—was used as the radiating structure. The diameters of the disks were modulated as a function of position along the rod, thus modulating the phase velocity along the array. The printed counterpart of this antenna is shown in the bottom of Fig. 8. It consists of a series of metal strips etched on a dielectric sheet. Note the modulation of the element lengths.

In general, the elements have a length between 0.3 and 0.4 wavelength, and the spacings are about 0.2 to 0.3 wavelength. Spacings as close as 0.05 wavelength have been used for the first few elements, and lengths as short as 0.15 wavelength have been used on end tapers with good results. These arrays are energized with a dipole-and-reflector assembly and are usable over a band of at least 20 per cent. The performance of a 16-wavelength ladder antenna consisting of 88 elements is summarized in Table 2. *This paper was originally presented at the 1957 I. R. E. Convention.*

Reference

E. G. Fubini, J. A. McDonough and R. G. Malech, "Stripline Radiators," 1955 I.R.E. Convention Record, Part I, page 51.

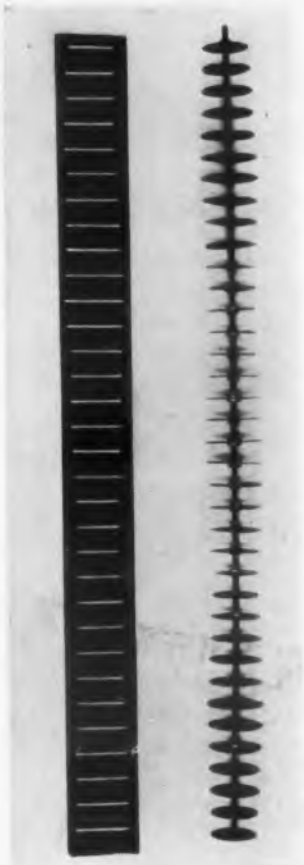
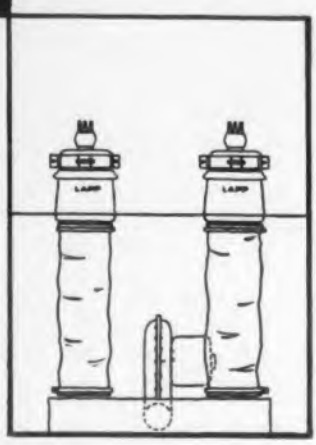


Fig. 8. Cigar antenna of the Simon-Weill type and derived printed ladder antenna. These radiators are eight wavelengths at S-band frequencies.

Lapp

TUBE SUPPORTS for air-cooled power tubes



Since forced-air-cooled tubes were first introduced, equipment manufacturers have been designing their own supports, many of which have been produced by Lapp. To standardize the great variety of tube support designs, Lapp set out to design a complete line which is now available and offers the equipment manufacturer a valuable service by way of more economical production, interchangeability and availability of replacement units. Lapp Tube Supports are compact, efficient and attractive in appearance. Their duty is threefold . . . they support the tubes, insulate, and furnish an air duct which channels air over tube fins for maximum cooling. Write for Bulletin 301, with complete description and specification data. Lapp Insulator Co., Inc., Radio Specialties Division, 945 Sumner Street, LeRoy, New York.

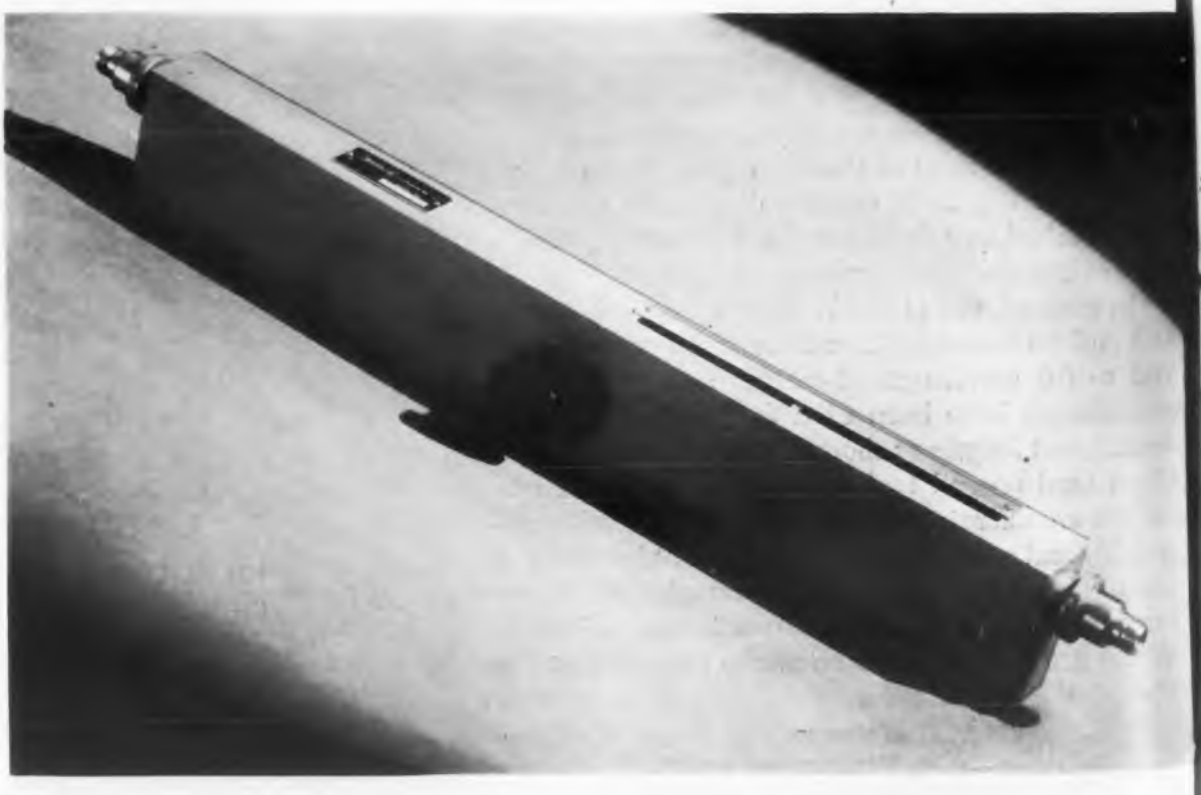
Lapp

CIRCLE 33 ON READER-SERVICE CARD FOR MORE INFORMATION

Continuously Variable Coaxial Attenuator

AN INSERTION loss of only 1 db for this coaxial attenuator compared with a minimum of 15 to 20 db for previous piston type models, will reduce signal generator requirements from 30 to 100 times. Dial calibration does not vary more than ±.25 db over a two to one frequency range. Models are made for any octave bandwidth from 100 to 3300 mc.

Varying rf power in the uhf and microwave spectrum, when utilizing rigid coaxial line, has previously been done with a piston type attenuator. In such a unit the attenuation factor is theoretically



Variable coaxial attenuator has a range from 1 db to 40 db.

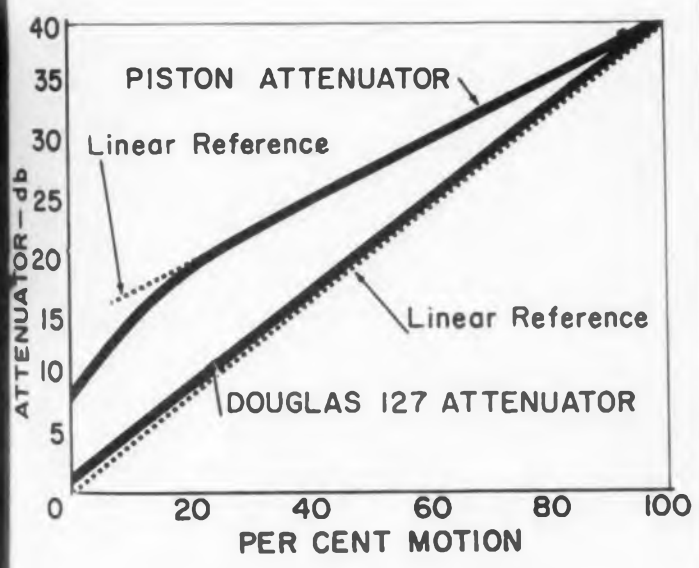
predictable and will give a linear attenuation versus motion. Below a minimum value of approximately 15-20 db, (see graph) linearity of attenuation no longer exists, and the input match (vswr) is very high. Use of a piston attenuator has necessarily meant that the signal source or signal generator must supply 15 to 20 db more power than is required at the output terminals of the attenuator. This is approximately 30 to 100 times the power needed.

The Model 127 continuously variable attenuator developed by the Douglas Microwave Co., 252 East 3rd Street, Mount Vernon, New York, overcomes this disadvantage with an insertion loss of only 1 db. In many applications this means that a signal generator which formerly could supply only 1 mw of power can now supply up to 100 mw.

Cavity "Q" measurements can be accurately made using the model 127 attenuator. When making half power point measurements variation of rf power output noted on a square low detector will be in error if the detector is not operating in the square low region. Since the attenuator is not susceptible to this error it is capable of more accurate measurements in these regions.

Fixed coaxial attenuators can be calibrated with the Douglas 117 without using the high gain receiver usually required. The detection means can be a bolometer or thermistor operating at comparatively high levels. Power handling capabilities of the attenuator are 10 w average and 10 kw peak with a .001 duty cycle.

For further information on this coaxial attenuator turn to Reader's Service Card and circle 34.



Attenuation vs Motion

Douglas 127 coaxial attenuator is linear within ±.25 db over complete attenuation range. Piston attenuator has a high insertion loss and does not become linear until approximately the 20 db point.

This is the second part of a two-part article on a subject of increasing importance to the practicing design engineer. Last issue the basic principles of cooling were discussed, as well as methods of natural air convection and metallic conduction. In this part of the article, other methods of cooling are described in detail together with design data to aid in selecting the right method for a particular design application.

Cooling Packaged Electronic Equipment—II

Selecting The Method of Cooling

A. Donald Hay, Chief Engineer
McLean Engineering Laboratories
Princeton, N. J.

Forced Air Cooling

Cooling electronic equipment through the use of forced convection of air, such as in Fig. 1, is very widely used and fairly easy to accomplish after recognizing the basic rules. This method removes more heat than by natural air convection or metallic conduction but does not require much extra equipment. With this method it is necessary to provide sufficient air velocity to cut down the thickness of the air film surrounding the hot electronic component to such a point that the heat can pass through it with the available temperature difference across the air film. It is also necessary to provide a sufficient quantity of air to carry away the heat removed with a moderate average temperature rise (normally 10 C) of the air circulated.

For forced convection the Grashof number is replaced by the Reynolds number, the ratio of inertia forces to viscous forces, in computing the air film coefficient. A convenient approximation[7] for determining the air film coefficient under standard conditions is:

$h_c = 1 + 0.22V$, for $V < 16$ fps

$h_c = 0.53\ V^{0.8}$, for $16 < V < 100$ fps

where h_c is in Btu/(hr—ft²—F°) and

V is in ft/sec

The quantity of air required in cubic feet per minute to carry away the heat by convection at standard air conditions is:

$$\text{cfm} = \frac{\text{Btu/hr}}{1.08(\triangle t_F)} = \frac{3170}{(\triangle t_F)}\ \text{kw}$$

$$= \frac{\text{Btu/hr}}{1.94(\triangle t_c)} = \frac{1760}{(\triangle t_c)}\ \text{kw},$$

where the heat is expressed in kilowatts or Btu/hr and the temperature rise of the air is in Fahrenheit or Centigrade degrees.

It is of design interest to note that whenever air increases 10 degrees Centigrade, the relative humidity of the air is approximately cut in half. The above equations indicate that, for a design average temperature rise of the circulated air of 10 degrees Centigrade, 176 cfm of air is required per kilowatt of heat dissipated. Electronic components which must be kept coolest should be located near the inlet air and in a high velocity air stream, while

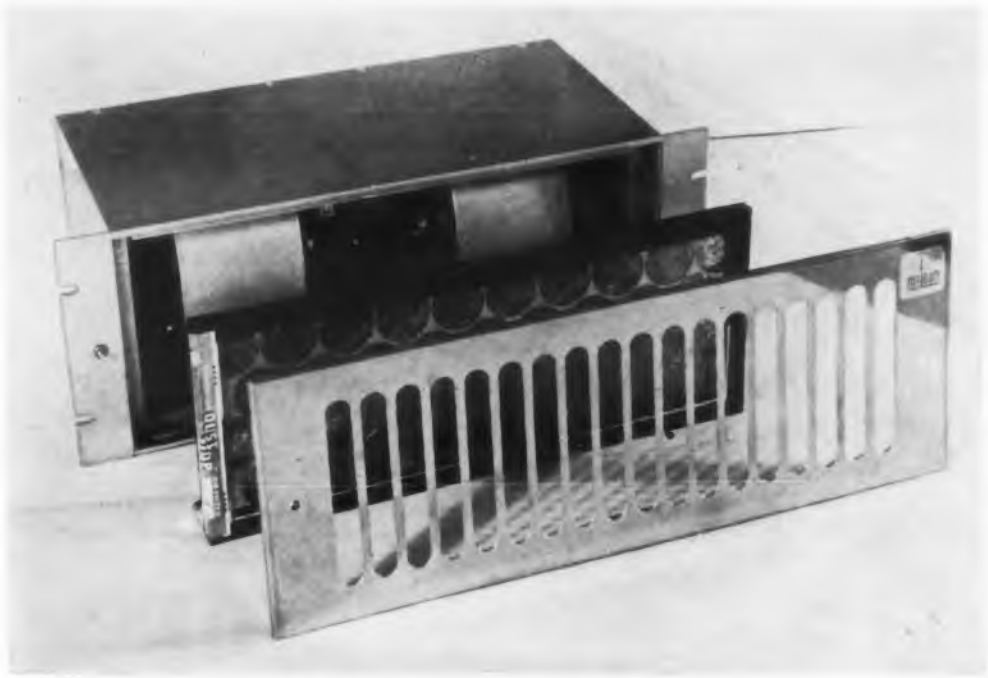


Fig. 2. Forced air cooling unit designed for track mounting. Filter is easily replaced by removing two screws which attach grill. Unit can be mounted in any location in standard relay rack or cabinet.

Fig. 1. Typical electronic equipment forced-air cooler. Blowers at bottom of cabinet bring air in through filters and force it out through top of cabinet.

components which operate best when surrounded by dry air should be located near the air outlet.

Forced air cooling works best when the dust is filtered from the air to keep dust and fuzz from the hot surfaces, thus improving the heat transfer, and also maintenance. The entering air is normally filtered and then run through a blower before cooling the equipment. This pressurizes the electronic rack or cabinet to prevent other dust from entering through cracks. At times a filter is placed in the outlet grille to keep out dust when the blower is not operating. Packaged blower units providing filtered air may be purchased in the standard modular sizes for insertion in the standard electronic racks to cool the other rack components. One such component is shown in Fig. 2. The inlet grille is flush with the front of the rack. Another system is to fabricate an electronic rack extra wide and pass ducts up each side, from which cooling air is distributed to the various levels of components. Either a propeller or a centrifugal blower could be used for this purpose, but if a filter is employed the blower has the great advantage of maintaining air delivery against pressure. It runs more quietly, delivers air at a greater velocity, and continues to deliver air when the filter becomes dirty.

Forced-air cooling may be used in either of two ways in a hermetically-sealed system. One way is to force air through an internally finned panel on which the warm components are mounted, and the heat is removed with the aid of metallic conduction from the component to the cooling air. The other is to have two air circulating systems. An internal hermetically-sealed blower recirculates dry air past the warm components and also the entire inner surface of the container. Around this inner container is mounted a second container, and a second blower circulates air in the normal manner between the containers. The judicious use of finned surfaces can increase the flow of heat. If this lacks sufficient capacity, a heat pump may be employed.

Performance Limitations

There are performance limitations in selecting a fan or blower for a specific use. In considering some of these, as an aid to understanding the performance and selecting the appropriate equipment, the most important fan or blower laws are as follows:

For constant impeller size, type, and air density,

- the discharge is proportional to the impeller speeds,
- the pressure is proportional to the square of the speeds, and
- the input power is proportional to the cube of the speeds.

For constant impeller type, speed, and air density, and all dimensions changed proportionately,

- the discharge is proportional to the cube of the diameters,
- the pressure is proportional to the square of the diameters, and
- the input power is proportional to the fifth power of the diameters.

These are useful relations but they can be used to derive a much more important relation. Because input power is proportional to the diameter squared and the pressure to the 3/2 power, and also to the discharge times the head, these quantities may be combined into a dimensionless ratio called specific speed, N_s. The equation is:

$$N_s = \frac{N\sqrt{Q}}{(g\triangle H)^{3/4}}$$

where N is the rotating speed, Q is the rate of discharge, g is the acceleration of gravity, and $\triangle H$ is the pressure head of fluid flowing across the unit in any consistent set of units. Knowing the specific speed of a pump, turbine, propeller, impeller, or similar device will define its efficiency and performance. Each type of device has a reasonably good efficiency over a certain range of specific speeds and a maximum efficiency near the center of the range.

The specific speed, n_s, is sometimes expressed by

$$n_s = \frac{n\sqrt{q}}{h^{3/4}},$$

where n must be rpm, q must be in cfm, and h must be the differential static pressure across the equipment measured in inches of water. Here n_s is not

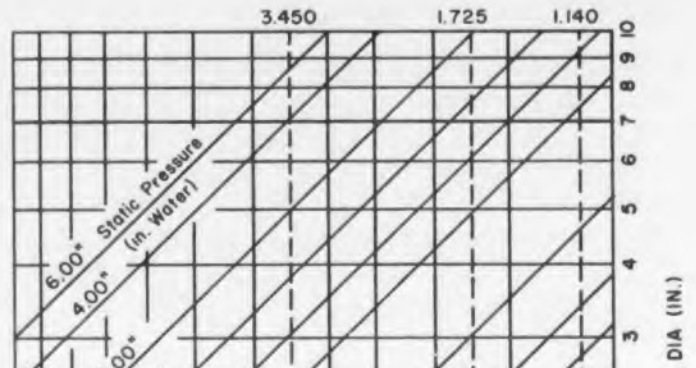


Fig. 3. Impeller Performance

dimensionless. (For hydraulic equipment, q is usually in gpm, and h is expressed in feet of water.)

The propeller fans used for electronic cooling normally have from 3-5 blades, and the air flows approximately parallel to the axis of rotation. For the squirrel-cage and the radial wheel blowers, the air leaves the rotor radially as a result of centrifugal force imparted to the air. The blades of the latter extend further in a radial direction, providing more bite on the air and a greater pressure. The mixed flow fan is a transition between the axial and radial flow units. The specific speeds to which these types should be matched for acceptable performance are shown in Table I.

Example

As an example, what type of equipment should be used for seven inches in height available (permitting a 6-inch propeller or a 4-inch rotor on a squirrel-cage blower), 60 cycle current (permitting 1650 or 3300 rpm), 0.3 inches of water column pressure (for filter and equipment), and a desired 144 cfm. The specific speed for the 1650 rpm application is 49,500 which indicates a squirrel-cage blower, and that for 3300 rpm is 99,000, indicating a mixed flow fan. Knowledge of the size of the propeller or rotor is not yet needed.

Table I

Range of Application For Different-Type Blowers

Type of Unit	Specific Speed	
	N_s	n_s
Propeller fan	0.650—2.61	100,000—400,000
Mixed flow fan	0.325—0.818	50,000—125,000
Squirrel-cage blower	0.0588—0.458	9,000—70,000
Radial wheel blower	0.262—0.131	4,000—20,000

The relation between pressure, impeller diameter, and impeller speed is shown in Fig. 3. This brings in the other variable—size. It may be seen that for the speed and pressure assumed in the above example, an impeller 4 inches in diameter is suitable.

The horsepower input to a fan or blower may be approximated from the relation:

$$hp = 0.0001575pQ/0.75 ,$$

where p is the total pressure in inches of water, Q is the discharge in cfm, and 0.75 is a representative efficiency for proper values of specific speed.

Sufficient filter area should be allowed so that the air velocity through the filter shall be between 300 and 400 fpm for normal filters and between 450 and 550 fpm for high velocity filters. This assures that the dust will strike with sufficient force to stick but yet will not be pulled through the filter. There remains the check in the performance curves of the manufacturer for the test results of his particular unit.

The resistance of clean filters will vary from 0.05 to 0.20 inches of water for normal use. If ducts or air passages are used, the air velocity should be kept below 1200 fpm for quietness. Turbulence should be kept to a minimum in the passages but encouraged at the heat transfer surface.

Blowers should be installed so that the air enters the blower inlet symmetrically and without rotation. This is generally accomplished by installing the impeller at the center of any enclosure around the blower scroll or by installing appropriate guide vanes to direct the air. For a double inlet blower the clearance between an inlet side of the blower scroll and a parallel surface of obstruction should be at least one third the diameter of the impeller in order to maintain rated performance. If the clearance is only one fourth the diameter, the impeller speed must be increased 4 per cent, and if one fifth, by 10 per cent, in order to achieve rated performance based upon no obstruction. For single inlet blowers or adjacent double inlet blowers this clearance distance must be doubled.

If propeller fans are to operate against absolutely no static pressure, they will move the most air if not surrounded by any form of orifice. If the air must be forced through a filter, heat exchanger coil, or other device offering resistance, a diaphragm with some form of orifice for the propeller is necessary to direct the air. Except for very high velocity fans, whether the orifice is sharp edged, rounded entrance, or tubular is of secondary importance. However, for any of these orifices one should strive to adjust the position of the propeller so that one third of its axial depth protrudes through the end of the orifice. For optimum operation the clearance between the tip of the propeller blade and the orifice should approximate 2 per cent of the diameter of the propeller.[8]

Direct Liquid Cooling

Another basic method of cooling electronic equipment is through the use of liquid cooling. When liquid-cooled plates are used, the fluid is usually fresh water. Normal water velocity in pipes and heat exchangers is five feet per second. If recirculated, a pump and heat exchanger are needed to withdraw the heat to a sink. If the heat exchanger is air cooled, the air velocity over the finned coils should be 500 fpm, and the internal liquid velocity should be 5 fps. The film coefficient for water is about 100 times greater than for air, and the heat carrying capacities per pound and per unit volume are much greater. If direct immersion of the electronic component is desired, a silicone fluid is greatly preferred for its many suitable electrical and mechanical properties. The principles involved are much the same as for natural and forced convection of air except that the liquid must not leak out of its prescribed chambers and a separate heat exchanger to cool the liquid is often required.

Vaporization Cooling

The most effective method of removing great concentrations of heat is by vaporization cooling. This is accomplished by a change of state utilizing the latent heat of vaporization to remove the heat. This is normally accomplished in a hermetically–sealed or safety–sealed system. If water at standard atmospheric pressure were to be used in what might be called liquid potting, the previously discussed heat transfer methods would preside until the water reached 212 F, at which time if more heat were added the water would boil, absorbing much heat. Actually, for indirect cooling this amounts to a steam boiler and has limited use. It is more usual to use one of the lower-pressure Freon gases, such as F-11 and F-113. At atmospheric pressure the saturation pressure of F-11 is 70 F, and for F-113 is 120 F. The potting fluid is often F-113 in a hermetically-sealed container. A space for F-113 vapor is left in the container. When heat is absorbed by the liquid F-113, vapor bubbles are formed, which increases the internal pressure establishing a new and higher saturation temperature or boiling temperature. In such a system the heat must be removed from the F-113 by some means. This can be by water-cooling coils in the F-113 or air cooling on the hermetic case. Lacking these, a safety valve is likely to blow or the case fail.

REFERENCES

1. *Guide*, American Society of Heating and Ventilating Engineers, 1956.
2. Technical Information. The Torrington Manufacturing Co.

New Products

Miniature Vibrator

Resists 9000 G

A vibrator measuring 1-1/4 in. high, 3/4 in. diam and weighing 1-1/2 oz has been designed to meet extreme requirements for reliability and environmental conditions. Shock tests have proven the 1900 Series vibrator to have satisfactory operation after shocks of 9000 g and up. One performed satisfactorily after being subjected to a shock of over 17,000 g. The vibrator was not affected by spin test accelerations from standstill to 13,000 rpm. Designed for intermittent service, the 1900 Series vibrator is a 400-cy full wave interrupter type, and can deliver up to 20 w for short periods. It operates at ambient temperatures from —60 to +100 C.

P. R. Mallory & Co., Inc., Dept. ED, Vibrator Div., DuQuoin, Ill.

CIRCLE 39 ON READER-SERVICE CARD FOR MORE INFORMATION

Dual Pulsing

Variable Spacing and Duration

The Dual Pultrator, a test unit providing two pulse trains with variable spacing and duration times, is used in simulating radar returns from multiple targets, in simulating video circuitry of beacon systems and unsynchronized beacon replies for traffic and interference studies. Each train of ten pulses can be so interlaced that the effect of closely spaced pulses upon a delay line can be determined. In testing video amplifiers, the multiple pulse affords a variable source of signals for recovery and overload tests.

Pulses may be interlaced or positioned consecutively, with a pulse width range of 0.3 to 0.6 μsec and with spacing between pulses from 2 to 4 μsec. Delay of train from sync pulse is 10 to 200 μsec; rise time of each pulse is 0.06 μsec; and fall time of each pulse is 0.07 μsec. External trigger requirements are 5 to 200 v amplitude, a repetition rate of 1 to 5000 pps, and an input impedance of 100 K.

Packard-Bell Electronics Corp., Dept. ED, Technical Products Div., 12333 W. Olympic Blvd., Los Angeles 64, Calif.

CIRCLE 40 ON READER-SERVICE CARD FOR MORE INFORMATION

Industrial Triode

20 Kw

Type 6800 rf power amplifier and oscillator triode is designed specifically for heavy-duty industrial service in induction heating, dielectric heating and similar applications. The 6800 will deliver over 20 kw into industrial loads at frequencies up to 30 mc. It has a heavy-wall anode with high heat capacity, capable of absorbing intermittent overloads. The filament is of thoriated tungsten for longer life and low power drain. Since it is not designed for outstanding performance in the upper vhf and the uhf bands, it costs considerably less to manufacture than communications-type tubes of similar power capability.

Amperex Electronic Corp., Dept. ED, 230 Duffy Ave., Hicksville, N.Y.

CIRCLE 41 ON READER-SERVICE CARD FOR MORE INFORMATION

Dielectric Test Bridge

Plastics and Liquids

The Type FT-VKB Dielectric Test Bridge is designed specifically for measuring dielectric properties of sheet plastics such as bakelite, Teflon and polystyrene, and for analysis of the electrical performance of oils and other liquids. The bridge uses the standard Schering Bridge circuit, and permits satisfactory operation over a frequency range of 50 cps to 300 kc. Capacitance ranges from 10 μμf to 1 μf. Accuracy is ±1 per cent. Dissipation factor ranges from 0.01 to 10 per cent, and up to 100 per cent with range extension adapter.

Federal Telephone and Radio Co., Dept. ED, 100 Kingsland Rd., Clifton, N.J.

CIRCLE 42 ON READER-SERVICE CARD FOR MORE INFORMATION

Dummy Load

Wide-Band

The DS-58 (military designation AN/URM-58) dummy load is a 50-ohm termination with a single input used for transmitter outputs of 500 w over the continuous range of dc through 5000 mc. The DS-58 connects directly to type LC cable fittings, and adapters are furnished to provide for connection to type N and LN cable fittings. Low voltage standing wave ratios are featured with a maximum of 1.2 without adapters and a maximum of 1.3 with adapters. Radiator fins, which are cast integrally with the housing, provide a large interior surface as well as a large exterior surface area to adequately dissipate the 500 watts without a blower.

WacLine, Inc., Dept. ED, 35 S. St. Clair St., Dayton 2, Ohio.

CIRCLE 43 ON READER-SERVICE CARD FOR MORE INFORMATION

Transistor Decade Amplifier

Low Noise

The Model 40 Transistor decade amplifier provides a 10 meg input impedance and an output impedance of less than 5 ohms. Voltage gains of 10 and 100 are stabilized to within 0.2 db from 7 cps to 400 kc. Response is down 3 db at 2 cps and 700 kc. The maximum output capabilities are 3 v rms and 1 mw. Broadband noise referred to the input terminals is approximately 10 μv. The self-contained battery power supply is metered at the front panel and permits continuous operation in excess of 500 hrs. Dimensions are 7-1/2 in. x 4-1/2 in. x 5 in.

Zacharias Electronics Corp., Dept. ED, PO Box 172, Livingston, N.J.

CIRCLE 44 ON READER-SERVICE CARD FOR MORE INFORMATION

Constant Speed DC Motor

Accurate Control

Incorporating electronic speed regulation and degree by degree control of revolution, this motor is being used in battery-operated tape recorders. The motor and control is characterized by a permanent magnet rotor with multiple poles, a stator structure having a larger number of poles than the rotor, and the whole being driven by a tuned reed control circuit providing accurately regulated speed.

Size of the stepped case is 1-1/8 in. small OD, 2-1/8 in. large OD, and 3-9/16 in. overall length. Shaft has .120 in. diam and extends .750 in. Motor develops 2880 rpm with 100 cps source. Power input is 6 w, 6 v, and the output torque is .3 oz in. Speed regulation is 1 per cent with ±10 per cent variation in load, and 2 per cent with ±10 per cent variation in voltage.

J. C. Warren Corp., Dept. ED, 21 Hanse Ave., Freeport, N.Y.

CIRCLE 45 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Temperature Probe

For Missiles

This T-1305 aircraft total temperature probe, either boom or strut mounted, can be obtained with precision wire wound resistance elements with operating ranges up to 1000 F or with the thermistor type. Thermocouple elements are available for operation to temperatures of 2800 F. Employing the double stagnation principle the T-1305 has high recovery and negligible radiation and conduction errors. Data also indicate a low time constant. Probes of this type show complete insensitivity to 20 deg angle of attack.

Aero Research Instrument Co., Dept. ED, 315 N. Aberdeen St., Chicago 7, Ill.

CIRCLE 47 ON READER-SERVICE CARD

Oscillogram Reader

For Quick Inspection of Data

The oscillogram reader has the ability to transfer a trace directly from a record to a variable scale plotter, in order to present a quick "look-in" at data in process of compilation. Linear or non-linear calibration may be applied. Operation is direct and leaves minimum opportunity for operatór error.

Telecomputing Corp., Dept. ED, 16217 Lindbergh St., Van Nuys, Calif.

CIRCLE 48 ON READER-SERVICE CARD

Linear Amplifier

Non-Overloading

This non-overloading linear amplifier has 40 μsec recovery time after an overload of 1000 times. During the recovery period, incoming pulses are blocked in order to eliminate the possibility of inaccurate analysis. A change of line voltage from 95 to 125 v affects the gain by less than 0.5 per cent. Temperature stable resistors are employed for critical feedback coupling.

Baird-Atomic, Inc., Dept. ED, 33 University Rd., Cambridge 38, Mass.

CIRCLE 49 ON READER-SERVICE CARD

◀ CIRCLE 551 ON READER-SERVICE CARD

Accelerometers

0.03 to 40,000 g

A series of piezoelectric accelerometers, employing barium titanate in compression for operation over extremely wide acceleration and frequency ranges have recently been made available. The instruments have a natural frequency of 75 kc, a usable acceleration range from 0.03 to 40,000 g, a frequency range from 0.05 to 20,000 cps, and a sensitivity of 30 mv/g. Other pickups with various sizes, weights, mounting configurations and sensitivities are also available.

Columbia Research Labs., Dept. ED, Woodlyn, Pa.

CIRCLE 50 ON READER-SERVICE CARD

Automotive Amplifier

For Class A1, 12 V Operation

A miniature pentode, designed specifically for r-f and i-f amplification in automotive radio receivers, operates with heater, plate and screen voltages derived directly from a 12-v battery. The manufacturer warns that the supply should not be permitted to fall to less than 10.0 v, or to rise to more than 15.9 v. Heater current is 0.15 amp. Plate resistance in Class A1 operation is approximately 0.3 megohms; transconductance 1150 umhos and plate current 0.75 ma.

CBS-Hytron, Dept. ED, Danvers, Mass.

CIRCLE 51 ON READER-SERVICE CARD

Assorted Resistor Supply

For Lab or Shop

An assortment of carbon resistors, including 30 plastic boxes of the most used 1/2, 1 and 2 watt ratings, are packaged in an all-metal rack. The rack is suited to either bench or wall mounting. The buyer may choose from among 80 different resistance ratings. Hinged-cover plastic boxes make it easy to determine resistor color-coding and labeling. All the resistors meet all RETMA, MIL and ASESA specs.

G-C Electronics Mfg. Co., Dept. ED, 400 South Wyman St., Rockford, Ill.

CIRCLE 52 ON READER-SERVICE CARD

CIRCLE 53 ON READER-SERVICE CARD ➤

New Products

High Temperature Insulation

Glass and Resin

The T-9278 insulating material is made of flexible straight-weave continuous-filament glass fabric coated with a modified-silicone resin. Dielectric strength of the material as measured by the short-time, 1/4-in.-diam electrode method is 1250 v per mil at 1000 hours, 200 C.

Solvent resistance after 48 hours in both toluene and alcohol is good and after 48 hours immersion in 100 C oil no evidence of disintegration is observed. The new insulation has a 10-year life at 177 C based on extrapolated data. The material weighs approximately 1/2 lb per sq yd, is 0.007 in. thick and has a tensile strength of 164 lb per in. width.

Westinghouse Electric Corp., Dept. ED, Micarta Div., Trafford, Penna.

CIRCLE 54 ON READER-SERVICE CARD

Sealing Gaskets

Over 21-Inch Diameters

Seals of standard cross-section and in diameters from 21-in. up to any size, have now been made available through a recently-developed production method. The new technique is not used on rings less than 21-in. diam. Normal, close cross-sectional tolerances are maintained. Trademarked Quad Ring, these gaskets have no parting line on sealing edges, and are not subject to spiral twist failures, rolling with pulsating pressures, or leakage at low pressure differentials. They come in standard cross-sections—0.070 in., 0.103 in., 0.139 in., 0.210 in. and 0.275 in.

Minnesota Rubber & Gasket Co., Dept. ED, 3630 Wooddale Ave., Minneapolis 16, Minn.

CIRCLE 55 ON READER-SERVICE CARD

Transistor Analyzer

Scope Presentation

Basically a transistor curve tracer, the Model TA-13 traces as an oscilloscope presentation seven transistor characteristic family curves.

◀ CIRCLE 56 ON READER-SERVICE CARD

With a grounded base connection of npn, pnp, n or p type transistors it will show R_{22}—V_c vs I_c at constant I_e, R_{12}—V_e vs I_c at constant I_e, H_{12}—V_c vs V_e at constant I_e, H_{11}—V_e vs I_e at constant V_c, H_{21}—I_c vs I_e at constant V_c, and with a grounded emitter connection of npn and pnp junction transistors R_{22}—V_c vs I_c at constant I_b, H_{11}—V_b vs I_b at constant V_c. Direct meter measurement of α, β, I_{co}, and I_{eo} is also provided. It has a built-in current and voltage calibration axis generator, and a 450 μa to 450 ma input current range in 9 steps.

Polyphase Instrument Co., Dept. ED, E. 4th St., Bridgeport, Pa.

CIRCLE 57 ON READER-SERVICE CARD

Total Temperature Probes

For Missiles or Aircraft

Probes having a high recovery, small radiation and conduction errors, rapid response to temperature changes and complete insensitivity to attack and yaw angles up to 20 deg., have been developed and made available for use with a variety of sensing elements. The probes may be either boom or strut mounted. Sensing elements for use up to 1000 F may be either precision wire-wound or thermistors. Thermocouple elements can be supplied for operation up to 2800 F. The probes come in two models, designated T-1305 and T-1004.

Aero Research Instrument Co., Inc., Dept. ED, 315 N. Aberdeen St., Chicago 7, Ill.

CIRCLE 58 ON READER-SERVICE CARD

Thermoplastic Tape

Insulation

GT Tape is available in three types, as a polyester resin tape (without Mylar backing, with Mylar backing coated on one side with resin adhesive, or with Mylar sandwiched between two coatings of adhesive. It is supplied in a range of widths and gauges.

G. T. Schjeldahl Co., Dept. ED, Northfield, Minn.

CIRCLE 59 ON READER-SERVICE CARD

CIRCLE 60 ON READER-SERVICE CARD ➤

New Products

DC to DC Supply
Regulated

A transistorized dc to dc power supply measures 3 in. diam x 3 in. high, and weighs 19 oz. It operates from an input of 24 to 30 v dc. Outputs are available from 25 to 1200 v dc, with power up to 60 w continuous duty. This unit is regulated against both line and load variations. In a 50-w unit, line input variations of 22 per cent (30 to 24 v dc) are reduced to 1 per cent in the output. Load variations from 10 per cent to full load are similarly attenuated. Unit employs silicon Zener type reference diodes. No damage to the unit is caused by spikes in the line, or momentary overloads of ten to one of the rated power. Battery voltage transients are clamped by the use of avalanche-type diodes, and do not appear across the transistors.

Arnold Magnetics Corp., Dept. ED, 4613 W. Jefferson Blvd., Los Angeles 16, Calif.

CIRCLE 61 ON READER-SERVICE CARD FOR MORE INFORMATION

Glass Capacitors
High Voltage

The following comprise two lines of glass tubular capacitors. Type GML operates up to 85 C without derating over the range 0.002 μf and 1000 v dc to 0.03 μf and 12,500 v dc. Type GTL operates up to 125 C without derating over the range 0.001 μf and 2000 v dc to 0.03 μf and 10,000 v dc. These complex-dielectric, oil-filled lines are high in reliability and in insulation resistance, and are of miniature size for the voltage range covered. The endseals consist of tiny metal rings which are permanently bonded to the glass and metal discs which are soldered to the rings. The resulting leak-resistant seal offers the maximum creepage distance between terminals.

Dearborn Electronic Labs., Dept. ED, 1421 N. Wells St., Chicago 10, Ill.

CIRCLE 62 ON READER-SERVICE CARD FOR MORE INFORMATION

Relay

Sensitive at 6 Mw

A relay with a sensitivity range down to six mw is available in four header styles. The balanced armature relays operate where little power is available, as in vacuum tube circuits. Relays are available either as spdt or dpdt. In vibration tests dependability remained at 10 times gravity from 5 to 500 cps. Shock tests were delivered at 50 g while the relays were in operation, and they were found satisfactory from −65 C to 125 C. The relay's elements are hermetically sealed in inert gas to protect them from adverse environmental conditions. Standard contact material for the product is silver, rated at 2 amp for either 28 v dc or 115 v ac.

Iron Mfg. Co., Dept. ED, 2838 S.E. Ninth Ave., Portland 2, Ore.

CIRCLE 64 ON READER-SERVICE CARD FOR MORE INFORMATION

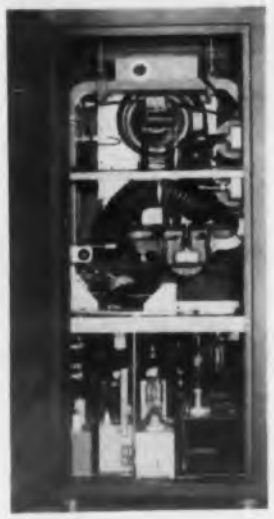
Circuit Breakers

Lightweight

These two miniaturized circuit breakers each weigh less than 1-1/2 oz. Twins in every respect except for the actuators, the breakers feature only three moving parts: actuator, slide and thermal disc. They are available with either toggle switch actuator (Model D7270-1) or a push-pull actuator (Model D7271-1). Other features of the circuit breakers include: high rupture capacity—tests to over 4000 amp, 120 v ac; simple, trip-free design, and a high current capacity glass melamine case with high arc resistance.

Metals & Controls Corp., Dept. ED, Spencer Thermostat Div., Attleboro, Mass.

CIRCLE 65 ON READER-SERVICE CARD FOR MORE INFORMATION



Magnetron Transmitter
650 Kw Peak

The G 15 Pulsed Magnetron Transmitter utilizes a RK-5586 tunable magnetron capable of 650 kw peak power over the band 2700 to 2900 mc. This particular unit produces fixed 2 μsec pulses at 60 cps but other versions are available for a wide range of pulse-width and repetition-rate characteristics. The unit shown was designed to drive a 30 megawatt S band klystron. It is equipped with a fixed 10 db high-power pad; a 20 db variable attenuator; three directional couplers for measuring incident and reflected power and observing the rf pulse; an rf dummy load; and all required metering, controls, and interlocks.

Levinthal Electronic Products, Inc., Dept. ED, 885 Stanford Industrial Park, Palo Alto, Calif.

CIRCLE 67 ON READER-SERVICE CARD FOR MORE INFORMATION

Product Tester
On-Off Cycles

This instrument provides means for making accelerated life tests on a wide range of electrical and mechanical devices. The Type 1000 Product Life Tester provides on-off power cycles that may be adjusted to any period from 1/10 sec to 15 min. Operates from 117 v, 60 cycle power, and will make and break circuits up to 15 amp. A counter is optionally available to register accumulated test cycles.

Paraplegics Mfg. Co., Inc., Dept. ED, 10068 Franklin Ave., Franklin Park, Ill.

CIRCLE 68 ON READER-SERVICE CARD FOR MORE INFORMATION

Magnetic Tape Truck

Protective Filing

This mobile unit houses, protects, and transports tape. Light enough so that it can easily be moved, it provides accessibility plus protection. There are two basic truck units. One is designed with either two or four reel sections of 25 bins each, accommodating a total of either 50 or 100 8-in. diam reels. The other is designed to accommodate the same number of 11-in. diam reels. Trucks are equipped with a locking device.

Remington Rand, Dept. ED, Div. of Sperry Rand Corp., 315 Fourth Ave., New York 10, N.Y.

CIRCLE 70 ON READER-SERVICE CARD FOR MORE INFORMATION

Magnetic Tape System

Versatile

The Type 5-752 magnetic tape recorder-reproducer system is designed to handle analog, pulse-duration and fm signals. Although developed specifically for telemetering of missile data, the system is expected to find use in research studies where high-speed acquisition of large amounts of precise data is required. It will also accept signals from self-generating transducers, strain gages, bridge-type transducers, etc., when transmitted through amplification equipment.

Seven individual tape tracks for the simultaneous recording of separate signals on 1/2-in. tape are provided. The system takes reels up to 14 in. in diam, has a capacity of 5000 ft of 1.5-mil tape, and is capable of handling 1/4-, 1/2-, 3/4- and 1-in. tape widths.

Consolidated Electrodynamics Corp., Dept. ED, 300 N. Sierra Madre Villa, Pasadena, Calif.

CIRCLE 71 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Pentagrid Converter

12 V Plate Potential

Designated 12AD6, a pentagrid converter intended for use as combined mixer and oscillator in a car radio, obtains heater, plate and screen grid potentials directly from the 12 v battery. It can tolerate variations of battery voltage from 10.0 to 15.9 v. Nominal heater current is 0.15 amp. In converter service, self-excited, plate resistance is approximately 1 megohm, conversion transconductance 260 μmhos, plate current 450 μa and cathode current 2000 μa. Oscillator characteristics (not oscillating) include transconductance between grid 1, and grids 2 and 4 connected to plate, of 3800 μmhos; and amplification factor between grid 1, and grids 2 and 4 connected to plate, of 9.0. The tube has a 7-pin miniature button. It has an external shield which connects to cathode and to grid 5.

CBS-Hytron, Dept. ED, Danvers, Mass.

CIRCLE 73 ON READER-SERVICE

Liquid Rosin Flux

For Production Soldering

Designed to meet military requirements for solder fluxes, and conforming to Signal Corps Spec MIL-F-14256 (Sig C) water-extractivity, polarized-wire and copper mirror tests, a recently developed liquid resin flux penetrates oxide films and other surface contaminants at a faster rate than ordinary resin fluxes. The solder can wet the cleaned metal surfaces and form sound joints in shorter time. Designated R-X3M activated liquid resin flux, the material gives 40 per cent more solder spread than pure plain resin fluxes, speeds production, decreases resoldering, and requires less supervision. R-X3M is non-corrosive both before and after soldering, and can be used on critical assemblies without risk of corrosion.

Federal Metals Division, American Smelting and Refining Co., Dept. ED, 120 Broadway, New York 5, N.Y.

CIRCLE 74 ON READER-SERVICE

◀ CIRCLE 72 ON READER-SERVICE CARD

Rosin Core Solder

Acts Faster

An activated rosin core solder, compounded specifically for faster assemblies and tighter joints, is now available from stock in 40/60 and 60/40 lead-tin combinations, in the common 0.062 diam wire, and in 1, 5 and 20-lb quantities on sturdy metal spools. Spread of this solder is 30 per cent greater than that of most conventional rosin core solders. Its activating chemical is not toxic to touch or respiratory tract and does not have an objectionable odor.

Federated Metals Division of American Smelting and Refining Co., Dept. ED, 120 Broadway, New York 5, N.Y.

CIRCLE 75 ON READER-SERVICE CARD

Airborne DC Relay

Resists Vibration

The 206W1 is a rotary-type, two-pole double-throw relay designed to withstand extremes of temperature, humidity and shock. It may be used at altitudes up to 80,000 feet.

It has palladium contacts, a precision-balanced rotary motor, and a one-piece extruded can with a silver-soldered mounting flange to insure high resistance to vibration and shock. In manufacture, the unit is evacuated, filled with gas and hermetically sealed. The unit contains an active getter to absorb residual gas and any organic vapors. Overall height of the 206W1 is 1.55 in. Its diameter is 0.634 in .

Radio Corp. of America, Dept. ED, 30 Rockefeller Plaza, New York 20, N.Y.

CIRCLE 76 ON READER-SERVICE CARD

Be-Cu Strip

Oxide Free

This oxide-free beryllium copper is available in thicknesses down to 0.0005 in., in tolerances of ± 0.0001 in., in widths from 3/32 to 6 in. in quantities from one pound to thousands. It can be stamped in the soft stage, and then heat-hardened.

American Silver Co., Inc., Dept. ED, 36-07 Prince St., Flushing 54, N.Y.

CIRCLE 77 ON READER-SERVICE CARD

CIRCLE 78 ON READER-SERVICE CARD ➤

MAKING...WITH ARALDITE EPOXY RESINS

• INSULATOR BODY of • NEW TYPE HIGH VOLTAGE BUSHING vacuum-cast in • ARALDITE® EPOXY-BASED RESIN

Dimensionally accurate . . .
Stronger and lighter than porcelain . . .
With better impact strength . . .
Cast with metal inserts.

READY TO USE
AS CAST
AS SOON AS
HIGH VOLTAGE CAP
IS ATTACHED

RATED AT 150 K.V. D.C.
185 K.V. R.M.S. (260 K.V. PEAK) TEST

PROBLEM: To cast internal stress control electrodes within the body of the termination on a simple, rapid production basis.

SOLUTION: "Epocast", an ARALDITE Epoxy-based resin formulated by Furane Plastics, Inc., met the demanding design and production "specs" set by Components for Research, Inc., Palo Alto, Calif. The basically excellent electrical and mechanical properties, high chemical/weather resistance, and the outstanding adhesive qualities of ARALDITE Epoxy resins may well hold the solution for you, too!

THERE'S MORE THAN MEETS THE EYE IN ARALDITE EPOXY RESINS. For all CIBA resins are checked not only for our rigid PRODUCTION quality control standards but the SPECIAL APPLICATION requirements of the user as well. The Technical Services of CIBA's Plastics Division are the finest in the field. For full information on how CIBA Araldite Epoxies lead to product development and production improvements, write . . .

CIBA COMPANY INC., Plastics Division — ED-6
Kimberton, Pennsylvania

Please send me full information on CIBA Epoxy Resins for

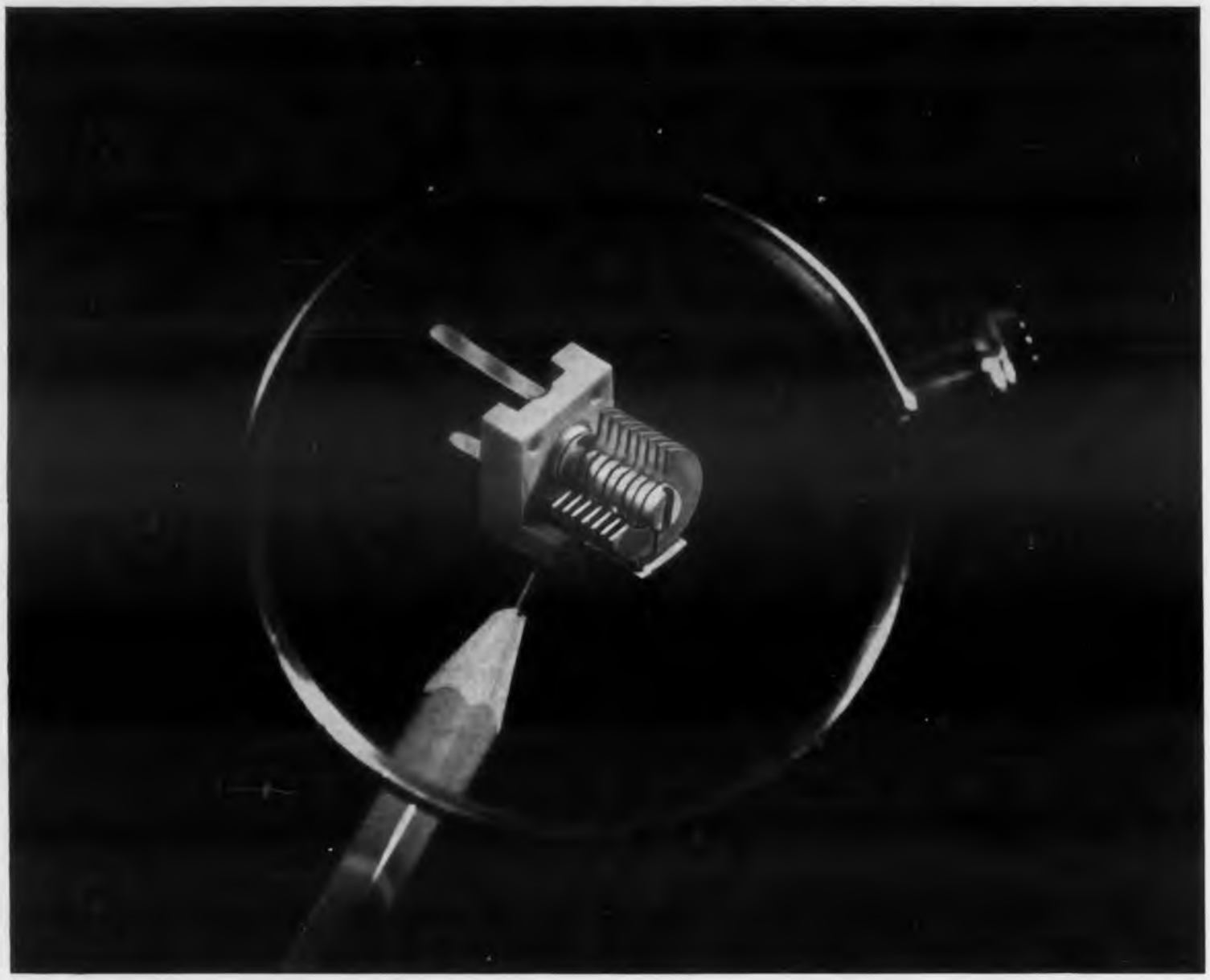
☐ Tooling ☐ Structural Laminates ☐ General
☐ Electrical ☐ Hi-Strength Adhesives ☐ Surface Coatings
☐ Plastic Body Solders

NAME _____

COMPANY _____ TITLE _____

ADDRESS _____

CITY _____ STATE _____



More than 1½ times actual size.

NOW! even smaller air trimmer capacitors

For every type of electronic equipment—printed wiring board or conventional chassis—Radio Condenser's new Series 75 trimmers mean more circuit in less space. Measuring just 25/64″ x 7/16″ x 17/32″ behind mounting surface, they're the tiniest trimmers ever made in the United States.

Three capacitance ranges are available, as tabulated below. Each is equipped with plug-in tabs for printed wiring board insertion, as well as two holes for conventional screw mounting. The sturdy low loss ceramic body, brass plates soldered and silver plated, assure a rugged unit, able to take extreme shock, vibration and temperature change. Capacitance is easily varied by means of a screwdriver slot in the rotor shaft.

Insulation resistance, "Q" and thermal stability characteristics are excellent.

Complete Engineering data and specifications for the new Series 75 Subminiature Trimmer capacitors are provided in Bulletin TR-123, available free on request. Write Radio Condenser now for your copy.

RADIO CONDENSER
MINIATURE AIR TRIMMER CAPACITORS

Type No.	Min. Cap. μμF	Effective Max. Cap. μμF	Air Gap	No. Plates
875001	1.2	5	.014	9
875002	1.2	10	.008	11
875003	1.5	15	.008	15

RADIO CONDENSER CO.

Davis & Copewood Streets • Camden 3, New Jersey
EXPORT: Radio Condenser Co., International Div., 15 Moore St., N.Y. 4, N.Y.
CABLE: MINTHORNE
CANADA: Radio Condenser Co. Ltd., 6 Bermondsey Rd., Toronto, Ontario

CIRCLE 79 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Fire Control Gyroscope

Measures Roll and Pitch

For use in aircraft fire control systems, this system measures displacement of the aircraft about the roll and pitch axes during flight and transmits this information to other components of the craft's control system. Vertical accuracy is maintained within ±1/4 deg during a continuous Standard Scorsby Operation. Also, it is within ±1/2 deg during vibration for 90 min along each of the major axes with double amplitude of 0.03 in. and 1 min cyclic sweeps between 10 and 55 cps. During normal operations erection rates are from 1 to 3 deg per min in roll and 1 to 4 deg per min in pitch. With the application of an external fast erection signal, the erection rates are increased to 150 deg per min simultaneously on roll and pitch axes to provide a fast recovery from any upset position.

Iron Fireman Mfg. Co., Dept. ED, Electronics Div., 2838 S.E. Ninth Ave., Portland 2, Ore.

CIRCLE 80 ON READER-SERVICE CARD FOR MORE INFORMATION

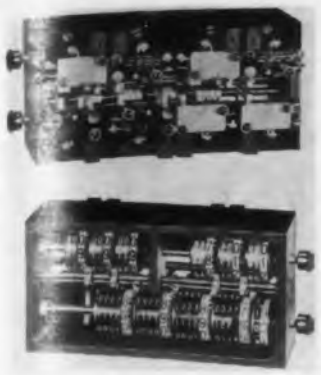
Tension Meter

20 lb Range

A light weight tension meter can be used for checking tensions during the processing of yarns, cords, and wires. The instrument has a range of one to twenty pounds, with good resolution at the low tension end. It features lever-inserting mechanism whereby two outer rollers are lowered or raised simultaneously. The controlling lever is at the side of the instrument away from the moving material, thus protecting the operator's hands, and the moving material is kept away from the observer at all times.

Tensitron, Inc., Dept. ED, Harvard, Mass.

CIRCLE 81 ON READER-SERVICE CARD FOR MORE INFORMATION



Programmer Counter

For Control Use

Application of the counter includes missile guidance systems and starting sequence systems, and wherever a plurality of switch contacts would be required at selective predetermined numbers. It can be mechanically set to give consecutive contacts at widely varied numbers. Setting of the predetermined numbers is accomplished by rotating the cam rings to the number desired. Conforms to military specifications and withstands very high impact and vibration tests.

Durant Mfg. Co., Dept. ED, 1993 No. Buffum St., Milwaukee 1, Wis.

CIRCLE 82 ON READER-SERVICE CARD FOR MORE INFORMATION

Indicator Lamps

Simply Mounted

Indicator lamp assemblies for simple panel mounting, consist of 24-v slide base telephone switchboard type lamp, plug in housing, tubular resistor, bezel and color caps supplied in red, green, amber, blue or white. Resistors supplied make them suitable for operation on circuits up to 250 v. Design allows installation in 21/32-in. holes in panels up to 1/4-in. thick by removal of threaded bezel and color cap. Long life lamps have nominal rating of 0.032 to 0.038 amp for use with resistors ranging from 110 to 7100 ohms. The tubular receptacle assembly is approximately 4-1/4 in. long and 1-1/16 in. in diam.

Federal Pacific Electric Co., Dept. ED, Eastern Switchgear Div., 888 N. Keyser Ave., Scranton, Pa.

CIRCLE 83 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Ceramic Foam

High Temperature Use

This ceramic foam is supplied to the user in a form resembling damp sand. It is packed or tamped into the cavity to be filled. After curing it can be subjected to up to 1600 F with only a slight decrease in strength. Foam structure is fine and uniform, with a density of about 20 lb/cu ft.

Emerson & Cuming, Inc., Dept. ED, 869 Washington St., Canton, Mass.

CIRCLE 86 ON READER-SERVICE CARD

UHF Twin Tetrode

Smallest

The Type 6939 twin-tetrode, an oval-base miniature tube designed for low-power uhf transmitter applications, has a seated height of 2-9/32 in. The tube delivers 5.5 w useful power in the load (ICAS rating) at any frequency up to 500 mc. It is claimed to be the world's smallest uhf twin tetrode. Frame-grid construction results in accuracy of interelectrode spacing.

Amperex Electronic Corp., Dept. ED, Communications Tube Div., 230 Duffy Ave., Hicksville, N.Y.

CIRCLE 87 ON READER-SERVICE CARD

Insulating Material

0.9 Mil Capacitor Grade

Developed for various types of capacitors, Isomica and Samica, micaceous insulating materials, are now available in thicknesses as fine as 0.9 mil. This is in addition to the 2 mil and 1.5 mil sizes previously available.

Possessing technically controlled electrical properties, capacitor grade Isomica is impregnated with selected high temperature silicone resins. Essentially the same material but without the resins, Samica can be impregnated by the user.

Capacitors using these materials are designed for operation at higher temperatures, presently up to 550 F, thus permitting a reduction in size of the finished capacitor. In stacked capaci-

◀ CIRCLE 85 ON READER-SERVICE CARD

tors these materials replace mica films with a consequent reduction in materials and labor costs.

Mica Insulator Co., Dept. ED, Schenectady 1, N.Y.

CIRCLE 88 ON READER-SERVICE CARD

High Voltage Fuse

8.7 Kv, 4000 Amp

A high voltage fuse designated 9F9D-9, isolates faulty units, allowing a capacitor bank to continue operation without danger of rupturing a failed capacitor. A fiber glass tube wall gives the fuse superior mechanical strength and a high degree of resistance to natural elements. This tube strength provides satisfactory operation of the fuse when the stored energy of an adjacent capacitor is four times greater than previously permitted.

It is installed by screwing one end into the buswork of a bank of equipment. A lead from the fusible element extends from the other end and is attached to the capacitor terminal. The 9F9D-9 fuse is rated 8.7 kv, 4000 amp.

General Electric Co., Dept. ED, Schenectady 5, N.Y.

CIRCLE 89 ON READER-SERVICE CARD

Pushbutton Switch

Keyboard Control

A typewriter pushbutton switch for manual keyboard control of equipment has been developed for rapid-repeat, one-finger operation. Low-force characteristics give the new switch both snap-action and tap-action. The switch, designated the 1PB81-T2, employs an spdt subminiature basic switch, which can be operated at frequencies up to 300 times per min.

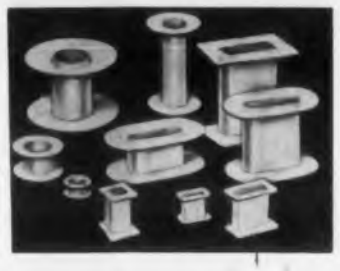
The switch is listed by Underwriters Labs. at 5 amp 125 or 250 v ac. The 30-v dc rating is as follows: inductive, 3 amp at sea level and 2.5 amp at 50,000 ft; resistive, 4 amp at sea level and 50,000 ft. Maximum inrush rating is 15 amp, 30 v dc.

Micro Switch, Dept. ED, Div. of Minneapolis-Honeywell Regulator Co., Freeport, Ill.

CIRCLE 90 ON READER-SERVICE CARD

CIRCLE 91 ON READER-SERVICE CARD ➤

New Products



Coil Bobbins
Nylon

Stock coil forms are produced in a variety of sizes in round, square, rectangular and oval shapes; sizes range from approximately 1/4 in. diam x 1/4 in. long minimum, up to 7/8 in. which is the largest size presently furnished from stock die elements. Nylon construction provides toughness, self-lubrication, high dielectric strength and insulating characteristics. Special requirements such as other-than-standard shapes, extra-precise tolerances, or bobbins with integral holes, hubs, projections, slots, etc., are also produced to order in quantities of 25,000 and over. Coil bobbins are also available on special order in other thermoplastics—Kel-F, Acetate, Polystyrene, etc.

Gries Reproducer Corp., Dept. ED, 400 Beechwood Ave., New Rochelle, N.Y.

CIRCLE 93 ON READER-SERVICE CARD FOR MORE INFORMATION

Tubing
New Shapes

Conventional round or oval cross sections are being superseded in many cases by cross sections of this alumina tubing resembling figure 8's. Often such designs have four or more holes, like figure 8's in tandem. Each tubular unit of the design may be joined closely to its neighbors—or separated by what might be termed ceramic webbing of various widths and thicknesses, resulting in a cross section comparable in shape to a dumbbell. Such designs have particular value for dispersing heat because of the reduction in mass of area; this is vital for electron tube applications. Materials are high-strength aluminas, of exceedingly fine grain size. Parts produced from these compositions are chemically inert. will not rust, corrode or deteriorate with time, and are nonmagnetic with thermal shock resistance. Single hole designs as small as 0.013 in. OD x 0.006 in. ID have proven practical in production quantities.

American Lava Corp., Dept. ED, Cherokee Blvd. and Manufacturers Rd., Chattanooga 5, Tenn.

CIRCLE 94 ON READER-SERVICE CARD FOR MORE INFORMATION

Staked Fastener
For Sheet Material

The Type M fasteners provide load bearing threads in thin, free flowing sheet material such as aluminum, brass, panel steels and copper. Shoulder types for maximum strength are available for panels .031 to .250 in. thick. Flush types (shown) fit panels .064 to .250 in. thick. The gripping strength is derived from the cold flow of the panel material into the recessed, knurled grooves of the fastener during installation. Installation is by standard presses, adjustable to pressure or stroke. The fasteners, being round, need no indexing.

My-T-Grip Mfg. Co., Inc., Dept. ED, 176 Broadway, New York, N.Y.

CIRCLE 95 ON READER-SERVICE CARD FOR MORE INFORMATION

Tube Tester
Complete Testing

Known as the model 539B, this instrument provides six micromho ranges: 60,000; 30,000; 15,000; 6,000; 3,000; and 600 μmho. In addition, a rectifier diode range and a voltage regulator range are provided. A choice of 4 ac signals (0.25, 0.5, 1 or 2.5 v) may be applied to the grid of the tube under test which is in addition to the dc bias on the grid. The equipment features a VR test which permits testing of voltage regulator tubes under actual operating conditions—to give a reading of striking voltage and simultaneous readings of regulating voltage and current. A short test measures the resistance directly in ohms (to 50 meg). The test set permits accurate matching of tubes such as 6SN7 when used in multivibrator circuits, and it also tests selenium rectifiers and germanium diodes. The gas test measures control grid current, thereby detecting any minute amount of gas in a tube. The efficiency of the cathode can be accurately evaluated to determine reserve capacity or future life of any tube. A noise test is included in the evaluation of a tube.

The Hickok Electrical Instrument Co., Dept. ED, 10525 Dupont Ave., Cleveland 8, Ohio.

CIRCLE 96 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Aluminum Inserts

Through Threaded

A line of through-threaded aluminum inserts for molding in plastics, rubber and ceramics are available in plain, brass plated and clear anodized aluminum. The Type B inserts have holes tapped with Class II threads to conform to ASME Specifications in thread sizes from 4-40 to ¼-28. Holes are reamed to close tolerances after tapping to facilitate placing inserts on locating pins in the dies. Both ends of the inserts are countersunk for use at either end and for easy handling without fumbling. A coarse outside knurl is provided for maximum holding power.

Yardley Precision Products Co., Dept. ED, 48 Afton Ave., Yardley, Pa.

CIRCLE 98 ON READER-SERVICE CARD

Flat Cable

Multi-Colored

Color coding is extended into the field of flat cable with a multi-colored flat cable called Spectrastrip. It is available in wire sizes 14 to 30, widths up to 3 in, stranded or solid, any color sequence and no limit on length. The cable will meet military specifications.

Organic Development Corp., Dept. ED, 10052 Larson Ave., Garden Grove, Calif.

CIRCLE 99 ON READER-SERVICE CARD

High Power Transistors

For Audio Amplifiers

Two high power transistors for the field of audio amplifiers have been announced. Designated the MN-24 and MN-25, the transistors have the ability to provide 30-35 db gain at less than 5 per cent total harmonic distortion when delivering 4 w of power. Quality control and improved production techniques give these transistors stability in time and temperature.

Motorola Inc., Dept. ED, 4545 W. Augusta Blvd., Chicago 51, Ill.

CIRCLE 100 ON READER-SERVICE CARD

CIRCLE 101 ON READER-SERVICE CARD

No. 2 of a series

Production and Quality Control

Skilled Personnel– There is no substitute for the skill and experience of the people who produce G-V Relays and Thermostats. The G-V Controls organization is a group who know their work is important, and who do it well. This is one of the prime factors responsible for the consistently high quality of G-V products.

p In Thermal Relays Help You?

Quality Control ranks high in the G-V organization. Uniformly high reliability of product is maintained through the most complete and modern inspection methods. Effective statistical quality control is used. Roving Inspectors constantly check all processes on an hourly sampling basis. Each part and material has its detailed specification. All instruments and gauges are checked on regular schedule against primary standards. Every relay receives its final test on automatic equipment. Complete type tests at regular intervals are made in G-V's Environmental Laboratory on the newest types of testing equipment. These factors, together with the care and skill of the experienced people who build G-V products, have made G-V Controls a trusted supplier to the country's major electronic and aircraft manufacturers.

Key spots open for engineers interested in going places with a young progressive organization.

G-V

Complete catalog data is available.

G-V CONTROLS INC.

18 Hollywood Plaza, East Orange, N. J.

Quality Control– All G-V Relays are given 100% automatic time tests on this equipment developed and built by G-V Controls.

Incoming inspection and hourly in-process checks on precision gauging equipment assure dimensional accuracy of all parts and assemblies.

Twin Triode

10,000 Hrs

Type E88CC/6922 frame-grid min ature twin triode, is one of the com pany's line of guaranteed 10,000 hou tubes. It features high transconduc tance, low noise and rugged construc tion. Principal uses are in cascode cir cuits, HF and IF amplifiers, mixer an phase inverter stages, and as a multi vibrator and cathode follower in com puters. Separate cathodes.

Amperex Electronic Corp., Dept ED, 230 Duffy Ave., Hicksville, L.I

CIRCLE 102 ON READER-SERVICE CARD

Pressure-Vacuum Control

0-180 psi

The type J17A Dual switch Pressur Control is an uncalibrated unit. Pres sure settings are made individually on each switch by adjustment screws Nine models are offered in a variety of adjustable ranges between O-180 psi limits, and maximum pressures up to 180 psi. On-off switch differentials are preset for values of 1 Hg to 1 psi dependent upon model. Switches may be set together to simulate double pole circuitry or set apart to obtain independent operation.

The J17A is available in any one of three standard types of switches: nor mally open, normally closed, or double throw with no neutral position Switches are rated for 15 amp.

United Electric Controls Co., Dept ED, 79 School St., Watertown, Mass

CIRCLE 103 ON READER-SERVICE CARD

Synthetic Paraffin

Cable Filler

For use as a filler between several wires forming a cable or in the covering of the wire, a synthetic paraffin called Paraflint has been developed. It has a dielectric strength of 760 v per mil at 60 cps. Dielectric constant at 60 cps is 2.33. Loss factor at 60 cps is 0.0005. Paraflint is a hard, hydrocarbon wax with a high melting point of 215 F.

Moore & Munger, Dept. ED, 33 Rector St., New York, N.Y.

CIRCLE 104 ON READER-SERVICE CARD

◀ CIRCLE 101 ON READER-SERVICE CARD

New Products

Cold Junction

Uses Compensating Bridge

A junction unit, of compensating bridge type design, provides constant-temperature reference at thermocouple cold junctions for industrial applications. These include data reduction systems, piloted aircraft, guided missiles, rockets and others. It measures 1-1/4 in. x 2-5/8 in. x 3 in., and weighs 12 oz. Potting after assembly in RTV Silastic provides shock immunity. Designated AutoRef, it is useful where temperatures vary widely. A third voltage, continuously equal and opposite to the reference junction voltage, is added to the circuit so that only measuring junction voltages are detected.

Thermo Electric Co., Inc., Dept. ED, Saddle Brook, N.J.

CIRCLE 106 ON READER-SERVICE CARD FOR MORE INFORMATION

Counter-Timer

Response of 1 cps to 100 Kc

Model 1400 is a five-decade electronic counter with response from 1 cps to beyond 100 kc. Measures frequency, period, time interval, and a ten-period average using a crystal-stabilized clock source having a maximum error of 0.001 per cent. Standard frequencies of 100 kc, 10 kc, 1 kc, 100 pps. 10 pps, 1 pps and 0.1 pps provide a maximum time resolution of 10 μsec and maximum gate interval of 10 sec. These clock pulses are available for external use through a front-panel connector. Features include a 25 mv sensitivity on frequency and period; continuously variable or infinite display time: three fully-regulated power supplies including counter tube anode regulation; separate start and stop input channels for time interval measurement with individual trigger level attenuators and slope selectors for positive or negative-going input waveforms.

Hupp Instrumentation, Dept. ED, 2119 Sepulveda Blvd., Los Angeles 25, Calif.

CIRCLE 107 ON READER-SERVICE CARD FOR MORE INFORMATION

Light Projector

For 8-Ft Distances

For use in photoelectric applications, this projector features small size, long bulb life, and has projection distances up to 8 ft. An indicator serves as an effective warning in case of lamp failure. The self-contained series limiting resistor provides lamp life expectancy of 1500 hr. The unit measures 4.5 in. from the base of the adjustable mounting bracket to the jeweled indicator, and 2.25 in. in width. The Model 6300 projector is designed for 6.3 v ac or dc input. An identical projector, Model 6275, operates on 12 v ac or dc.

Autron Engineering, Inc., Dept. ED, 1254 W. 6th St., Los Angeles 17, Calif.

CIRCLE 108 ON READER-SERVICE CARD FOR MORE INFORMATION

Recorder-Totalizer

Simple Design

The Model SR instrument provides a means for accumulating vital data on the operation of machines, processes or systems. A continuous sprocket driven strip chart maintains positive, accurate timing. There are no daily or weekly chart changes. Low cost replacement chart rolls, each containing 250 ft of continuous, chronologically printed chart. Available in a variety of speeds from 1 in. per hr to 10 in. per min. An elapsed-time meter registers accumulated productive time. The instrument can be provided with an operations counter instead of, or in addition to, the time totalizer. The stylus provided with each chart roll uses no ink and provides a clearly defined line. A transparent window allows viewing of the recorded chart, and it can be lifted to provide sufficient area for making notations directly on the chart. An external knob provides a means for setting the chart to the correct time of day.

Standard Instrument Corp., Dept. ED, 657 Broadway, New York 12, N.Y.

CIRCLE 109 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Time Delay Relays

Four Types

Four basic types of circuitry are used in these timers. Type 1 utilizes subminiature relays with slugged coils. Type 2 is used for short delay times and broad tolerance applications, and contains essentially resistance capacitor networks. Type 3 uses germanium transistors where maximum temperature requirements are 165 F and silicon junction transistors are used for units rated up to 250 F. Type 4 is used in long delays and requires the use of subminiature vacuum tubes for accuracy, stability and reliability. The timers can be divided into three basic classifications: delayed pull-in, delayed drop-out and pulse output.

Electronic Specialty Co., Dept. ED, 5121 San Fernando Rd., Los Angeles 39, Calif.

CIRCLE 112 ON READER-SERVICE CARD FOR MORE INFORMATION

Measurement Chamber

Shielded

This chamber is designed for delicate instrument measuring. It can be used under normal atmosphere conditions or can be furnished with reinforced walls and hermetic seals to permit pressure, vacuum and simulated altitude tests. The portable bench or field model attenuates ratios up to 1000 to 1 for low intensities and up to an infinite ratio for high intensities limited only by the number of magnetic shielding material layers used. Because the shielding material sheds magnetic forces, the unit does not become premanently magnetized. It can be adapted to closed circuit TV viewing for medical or specialized industrial viewing or to small aperture viewing.

Perfection Mica Co., Dept. ED, Magnetic Shield Div., 20 N. Wacker Drive, Chicago 6, Ill.

CIRCLE 113 ON READER-SERVICE CARD FOR MORE INFORMATION

Time Delay Relays
Compensated

Voltage variations and temperature changes have little effect on this relay's delay time because of its compensator. The M-200 standard relay, rated at 28 v, will remain practically constant in time over a voltage range of 24 to 32 v, and is not affected by temperature changes of −55 to +125 C. Delay times can be varied from 1/10 to 1 sec or from 1 sec to 5 min. Heater can be continuously energized. Relays can be supplied in voltage ranges from 2 to 125 v. All-metal construction withstands shocks to 50 g and vibration from 5 to 500 cps at 10 g. All units are ac or dc, single pole, either normally open or normally closed contacts rated at 3 amp.

Magna Electronics, Dept. ED, 15 Rockland Terrace, Verona, N.J.

CIRCLE 114 ON READER-SERVICE CARD FOR MORE INFORMATION

Chart Reader
Automatic

The Model 3800 moves a chart at a uniform rate, senses the position of the inked trace on the chart, and produces an output proportional to the ordinate value of the trace. Output is presented in the form of varying voltage, shaft rotation, changing digital numbers, or as a pulse-width modulated carrier. The present Model 3800 reader is designed to read standard charts from null-balance recorders; changes to adapt the unit for other functions will be made. Reading accuracy is ±0.1 per cent of the full scale.

The Geotechnical Corp., Dept. ED, 3712 Haggar Dr., Dallas 9, Tex.

CIRCLE 115 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Locking Inserts

Wire Thread

Easily installed, these units provide an answer to threaded fastening problems in miniature subassemblies where clearance or inaccessibility does not permit the use of external locking devices. The miniature 4-40 series eliminates the need for lock washers, lock nuts and locking wires by means of an integral gripping coil. The locking effect remains through repeated cycles of disassembly and a locked screw may be readily freed by applying break-away torque approximately the same as used in the original assembly.

The 4-40 insert is dimensionally stable and resists wear, corrosion, galling and seizing. Power inserting equipment can be furnished for continuous large volume applications.

Heli-Coil Corp., Dept. ED, Danbury, Conn.

CIRCLE 118 ON READER-SERVICE CARD FOR MORE INFORMATION

Magnetic Shift Register

Assembly Bits

Individual assemblies for custom fabrication of magnetic shift registers for computing, telemetering and communication equipment are now available. Using two assemblies per bit, the MRC unit cubes form a variety of shift register configurations with serial and/or parallel read-in and/or read-out. Operating currents for these assemblies are obtained from simple driver circuits. Read-out potentials are sufficient to directly trigger thyratrons. No external diodes are required. Two types are available, the first, the MRC-10, is a five winding assembly with a printed circuit base. The second type is a four winding assembly designed for use in standard nine-pin miniature tube sockets.

Magnetics Research Co., Dept. ED, 255 Grove St., White Plains, N.Y.

CIRCLE 119 ON READER-SERVICE CARD FOR MORE INFORMATION

Control Oven
For Whole Circuits

The AM-100 oven is designed to give exacting temperature control of more than just crystals. Entire circuits, components and/or complete subassemblies can be housed in one unit. The control oven features: lightweight construction (less than 7-1/2 oz); long life expectancy due to triple insulation on heater windings; stability of ±0.1 C; and standard octal plug-in (stud mounting available). The unit draws 20 w on initial warm-up. It meets vibration tests MIL-E-5272. Over-all diam is 3 x 5 in. high; cylindrical cavity is 1-3/4 in. diam x 2-3/4 in. high.

Bulova Watch Co., Dept. ED, Electronic Div., Woodside 77, N.Y.

CIRCLE 120 ON READER-SERVICE CARD FOR MORE INFORMATION

Analyzer
Pulse-Height

Model PA-400 is available in various capacities from 10 to 50 channels, in increments of 10 channels. Through building block design, a unit can be readily expanded to 50 channels as may be desired. Use of a triple-coincidence mode of operation permits error-free counting at continuous counting rates up to 15,000 counts per minute. A maximum of 99,999 counts may be stored in each channel. Readout is accomplished by a scale-of-ten glow transfer tube followed by a 4-digit register. Double pulse resolution time is 4 μsec.

El Dorado Electronics Co., Dept. ED, 1401 Middle Harbor Rd., Oakland 20, Calif.

CIRCLE 121 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Magnetic Memory Drum

Miniature

Over 12,000 bits of data and associated clock and reference information can be stored in this miniaturized unit. It measures 3-1/2 in. diam and contains 12 information channels plus clock and fiducial channels. Each channel is 0.070 in. wide with a capacity of 1024 bits. Clock and fiducial channels are an integral part of the aluminum drum, which is belt-driven with variable speeds to 15,000 rpm. Access time is approximately 1.25 μsec. It measures 6 in. diam x 3-1/4 in. OD.

BJ Electronics, Borg-Warner Corp., Dept. ED, 3300 Newport Blvd., Santa Ana, Calif.

CIRCLE 124 ON READER-SERVICE CARD FOR MORE INFORMATION

PM Motor

With Brake

A 1-1/4-in. PM gear reduction continuous duty drive motor has included in its design a positive action brake. Type 13-R-9105-01 combines motor, brake and gear train into a single integral unit. Coast of output shaft is reduced to 2-1/2 deg maximum from no load speed at 30 v dc. No load output is 5 to 10 rpm at 24 to 30 v dc, minimum stall torque 30 oz-in., operating temperature range —65 to +160 F and over-all length 3.89 in. plus shaft. The unit has flanged mounting and can be made to meet MIL-E-5272A.

John Oster Mfg. Co., Dept. ED, Avionic Div., Racine, Wis.

CIRCLE 125 ON READER-SERVICE CARD FOR MORE INFORMATION

Power Resistors

Seven Sizes

RSE Type resistors include five wattage ratings from 2 to 10 w, in seven various sizes, with resist-

and range of 0.5 ohms to 175 K, depending on size and tolerance. Precision tolerance of the resistors are 0.05, 0.1, 0.25, 0.5, 1 and 3 per cent. The RSE Type resistor is a wire wound precision resistor inserted into a nickel plated brass tube and surrounded by a resilient shock absorbing material. Applicable types conform to requirements of MIL-R-26-C. Maximum continuous operating temperature is 275 C. Substantial increases in power dissipation (up to 50 per cent) may be obtained when RSE resistors are clip-mounted to chassis.

Dale Products, Inc., Dept. ED, Columbus, Nebr.

CIRCLE 126 ON READER-SERVICE CARD FOR MORE INFORMATION

Tachometers

Motor and Generator

A line of motor tachometers and tachometer generators are for use in high-accuracy computers and servo systems. These units feature 0.12 per cent linearity from 0 to 4000 rpm, temperature compensation to ±0.3 per cent over operating temperature range of −55 to +80 C, and output voltage pretrimmed to ±0.2 per cent saving installation time. The tachometer generators can be combined with a choice of Size 15 and Size 18 low inertia servo motors.

Norden-Ketay Corp., Dept. ED, Commerce Rd., Stamford, Conn.

CIRCLE 127 ON READER-SERVICE CARD FOR MORE INFORMATION

Connectors

Lightweight

The KM series consists of lightweight miniature and subminiature connectors. Used with RG-59/U, RG-62/U and RG-71/U cables, these connectors have a peak voltage of 500 v and operating temperatures up to 450 f. Descriptions of the connectors are: Plug KM-51-01, Tee Adapter KM-91-02, Panel Jack KM-11-01 and Angle Plug KM-51-02.

Kings Electronics Co., Dept. ED, 40 Marbledale Road, Tuckahoe, N.Y.

CIRCLE 128 ON READER-SERVICE CARD FOR MORE INFORMATION

The Rheem REL-202 Transistorized Power Supply

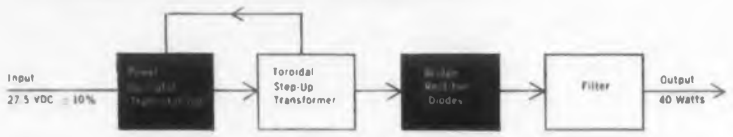
★ General description and use

The REL-202 Power Supply transforms standard 28-volt d.c. aircraft power to high voltage d.c. power for use with electronic equipment. It is an encapsulated, high-efficiency, solid-state device, combining semiconductors with a special magnetic core toroid. No moving parts or vacuum tubes are employed. It is built to withstand extremes of vibration and shock. By changing a single jumper in the external connector, a choice of three output voltages is provided. An R.F. filter prevents switching transients from being coupled into the d.c. bus. The REL-202 has been designed for combination with the REL-11 voltage regulator units.

★ General circuit description

There is a new use for the power transistor in the d.c. to d.c. power converter system in applying the transistor as a switching device. In the REL-202, the transistors serve as switches to obtain a square wave a.c. output voltage from a d.c. source. This a.c. voltage is stepped up through a toroidal wound transformer and then rectified to provide d.c. output voltage of a greater magnitude than that of the source d.c. voltage.

★ Simplified block diagram



★ General specifications

Input voltage and current:
Voltage— +27.5 VDC ±10%
Current—1.75 amp at full load output

Output voltage and current (determined by jumper position):
1. +350 VDC at 110 MA
2. +300 VDC at 130 MA
3. +250 VDC at 160 MA

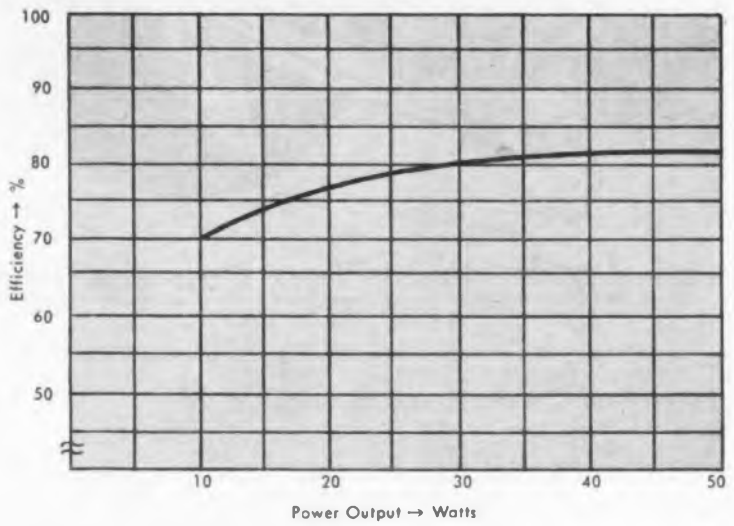
Output power: 40 watts

Output ripple: less than 1.5%

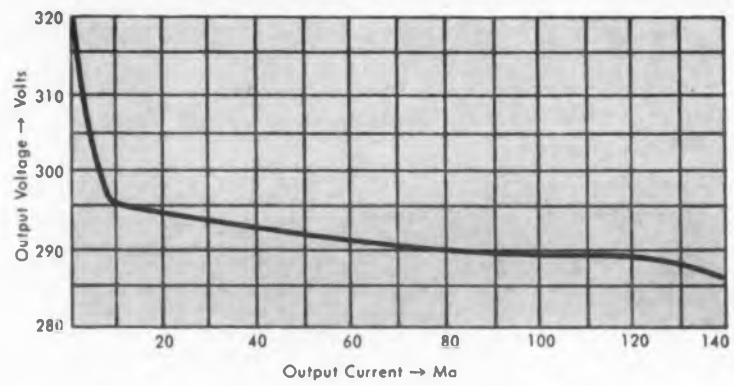
Regulation (for load variations):
3.0%—from 10% to full load

Operating temperature range (no derating):
−35° to +165°F

★ Efficiency curve *(overall input to output)*



★ Regulation curve



For further information, contact your area sales representative.

North Central	Florida	New England and New York State	Central East Coast	Southwest, Rockies and State of Washington
Sam Robbins, Inc. 230 East 1st Street Flint 2, Michigan	Arthur H. Lynch & Associates P.O. Box 466 Fort Myers, Florida	Electronics Associates, Inc. 200 5th Street Stamford, Conn.	F. R. Jodon, Inc. 8510 Beech Tree Road Washington 14, D. C.	George E. Harris & Co., Inc. 3241 East Douglas Wichita 8, Kansas

ELECTRONICS DIVISION/RHEEM MANUFACTURING COMPANY 7777 Industry Avenue, Rivera, California

CIRCLE 130 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Vinyl Coated Handle
For Cabinets

This aluminum handle is designed for use on military and high quality commercial electronic equipment cabinets. Supplied with heat treated mounting plate, the complete assembly carries 125 lb without distortion. Conforms with MIL-945A and NAVORD-OSTD 600 specifications. Overall length is 5-1/5 in.; height when raised is 2-5/8 in.; when lowered, 3/4 in.

United Technical Labs. Inc., Dept. ED, Morristown, N.J.

CIRCLE 131 ON READER-SERVICE CARD FOR MORE INFORMATION

400 CPS Frequency Meter
±0.25 Per Cent

Model #200 is designed in conformance with MIL-E-5400 and provides 0.25 per cent accuracy over the temperature range of −55 C to 70 C. The dial face is calibrated from 392 to 408 cps and may be mounted on an instrument panel with the tubeless electronics portion of the meter mounted elsewhere. The meter is designed to operate on 115 v with negligible voltage sensitivity at the center frequency.

Consolidated Avionics Corp., Dept. ED, Westbury, N.Y.

CIRCLE 132 ON READER-SERVICE CARD FOR MORE INFORMATION

Controller
Converts Temperature

Model 6365 controller features easy change from standard temperature ranges to special temperature ranges, or conversion to control functions such as pressure, displacement or acceleration. The controller can be used with temperature, pressure, ac-

celeration and displacement transducers. It offers temperature control through the range 0 to 250 F. Alternate temperature ranges can be furnished. A nominal control sensitivity of 1 F in the standard temperature range makes the unit applicable to critical chemical processes. Characteristic features of the unit include adjustable differential control, calibration dial lock, input and controlled power indicators, local fusing and dpdt heavy duty relay contacts which are accessible at the rear-mounted terminal strip.

Autron Engineering, Inc., Dept. ED, 1254 W. 6th St., Los Angeles 17, Calif.

CIRCLE 133 ON READER-SERVICE CARD FOR MORE INFORMATION

Decimal Computer

Dual Function

Designed to handle research and development problems as well as process business data for small and intermediate firms and organizations, the Readix computer is a pure decimal machine with built-in floating point. The small and intermediate firm or organization which cannot justify a computer for just research work can use this computer with the punched card and magnetic tape tie-in, to do payroll, labor distribution, sales analyses, etc.

J. B. Rea Co., Dept. ED, 1723 Cloverfield Blvd., Santa Monica, Calif.

CIRCLE 134 ON READER-SERVICE CARD FOR MORE INFORMATION

Galvanometer Amplifier

100 Mw Output

The REL-103 performs the functions of amplifying and impedance transforming low level signals from barium titanite transducers to a level and impedance suitable to drive fluid damped optical galvanometers and similar devices. An input impedance of approximately 100 megohms is required. An output level of 100 mw will drive 90% of the galvanometers now being manufactured. Signal levels from the transducers are such that a gain range from 10 to 30 is adequate. The gain of the REL-103 is continuously variable over this range.

Rheem Mfg. Co., Dept. ED, 7777 Industry Ave., Rivera, Calif.

CIRCLE 135 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Hydraulic Exciter
High Force

The MB hydraulic exciter system is capable of sinusoidal motion and has a maximum force of 60,000 lb, an available stroke of 4 in., and a maximum velocity of 14 in. per sec in the frequency range of 1 to 150 cps. The exciter has five basic components: the driving head (upper left in photo), hydraulic accumulator (center) and (not shown) a high-pressure hydraulic pump, electronically controlled servo valve, and an electronic control system. Design of the hydraulic system is virtually identical for all exciter ratings, the limits of force, stroke and frequency depending on the capacities of the servo valve actuating cylinders and hydraulic pump.

MB Manufacturing Co., A Division of Textron Inc., Dept. ED, New Haven, Conn.

CIRCLE 138 ON READER-SERVICE CARD FOR MORE INFORMATION

Glass Brick Shielding
Transparent

Radiation shielding is built with a brick that is as dense as iron, and two thirds as dense as lead. Used as an insert in a metallic or concrete wall, the lead glass brick enables the worker to observe the action, perform remote manipulations, and read instruments behind the wall shield. Three sizes of brick are cast, including a large 8 x 8 x 4 in. square block for maximum viewing angle. The bricks are composed of a special lead glass mixture, and are mounted in a steel frame for protection and handling.

The Atomic Center, Inc., Dept. ED, 489 Fifth Ave., New York 17, N.Y.

CIRCLE 139 ON READER-SERVICE CARD FOR MORE INFORMATION

System Calibrator

Thermocouple Control

The Model TC2 Thermocouple Control Unit makes possible temperature calibration and sensitivity adjustment in multichannel recording systems. This unit couples as many as twelve thermocouple measuring circuits, each to its recording element, (usually an oscillograph galvanometer), and provides for the injection of known voltages to produce temperature calibration traces. A reference temperature base is also provided through a separate bucking voltage source included in the control unit. The unit measures 7 1/2 in. W x 11 1/2 in. H x 8 in. D and weighs 5 lb.

Pace Engineering Co., Dept. ED, 6914 Beck Ave., North Hollywood, Calif.

CIRCLE 140 ON READER-SERVICE CARD FOR MORE INFORMATION

Vibration Test System

Operated at 500 F

The Model 2242 Accelerometer, Model 2615 Cathode Follower and Type 3090 Connecting Cable have been specifically designed to operate in ambient temperatures to +500 F without cooling or correction. Through of the use of the newly developed Piezite element type II, Model 2242 Accelerometer provides a minimum sensitivity of 8 mv per g for high signal-to-noise ratio even at low g levels. Response is down only 3 per cent at 500 F. Model 2615 Cathode Follower together with the new 3090 all Teflon, noise treated cable can be used in 500 F ambients close to accelerometer and thus avoid loss of signal caused by long cables. The electronic parts of the cathode follower are hermetically sealed in an inner housing which is vibration isolated from the outer case providing a low noise system. Cathode follower gain is 0.94. It weighs 4 oz and is 2.4 x 1.1 in.

Endevco Corp., Dept. ED, 161 E. California St., Pasadena, Calif.

CIRCLE 141 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Galvanometer Amplifier

Four Channel

The System D is a four-channel amplifier package which includes power supply, and is used with wire strain gages, transducers, thermocouples, etc. It will drive low-sensitivity, high frequency galvanometers, and provides excellent linearity over a wide range of input voltages. Features include: balanced input, high output (±60 ma), phase sensitivity, high stability, low noise level, overload indicator and protector, and no operational delay when overloaded. The System D gives fine resolution with a 20-step attenuator and gain control permits full-scale galvanometer deflection for input voltages between adjacent attenuator settings.

Allegany Instrument Co., Inc., Dept. ED, 1091 Wills Mountain, Cumberland, Md.

CIRCLE 144 ON READER-SERVICE CARD FOR MORE INFORMATION

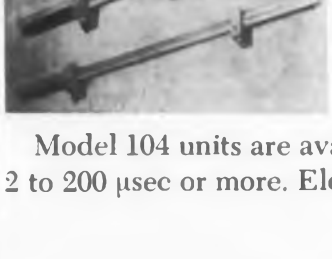
Transformer Line

Miniaturized

A complete line of audio transformers for transistorized circuit applications consists of 32 items comprising two series: a 150 mw series 21/32 in. H x 1-5/8 in. W x 13/16 in. D with mounting centers 1-5/8 in. Weight of each series is 0.6 oz and 1.1 oz respectively. The units come individually packaged in plastic containers, and are readily adaptable to printed circuits.

Gramer Halldorsen Transformer Corp., Dept. ED, 2734 No. Pulaske Rd., Chicago 39, Ill.

CIRCLE 145 ON READER-SERVICE CARD FOR MORE INFORMATION



Fixed Delay Lines

Magnetostrictive

Model 104 units are available in fixed delays from 2 to 200 μsec or more. Electrical characteristics may

be specified by the user, and intermediate outputs may be incorporated. They are resistant to shock and vibration. Terminal blocks measure only 1-1/2 x 1-1/4 in., while the tubular casing, dependent upon the delay factor, can be up to several feet long.

Deltime, Inc., Dept. ED, 608 Fayette Ave., Mamaroneck, N.Y.

CIRCLE 148 ON READER-SERVICE CARD FOR MORE INFORMATION

High Temp Capacitors

Industrial Use

A line of high temperature, glass-coated ceramic capacitors will allow components to operate in temperature environments up to 350 F. The glass-coated capacitors are said to outperform other capacitors that currently suffer heat shock in the chemical and other allied processing industries. The Glennite capacitors are stated as providing greater moisture resistance, increased reliability of operation and better corona suppression. Construction features a fused, nonporous layer of glass, over thin-sheet barium titanate ceramic capacitors. Pure silver leads are easily soldered and provide resistance to oxidation at high temperature uses. The components are presently available in all ranges and values of standard temperature compensating and high compensation ceramic capacitors.

Gulton Industries, Inc., Dept. ED, Metuchen, N.J.

CIRCLE 149 ON READER-SERVICE CARD FOR MORE INFORMATION

Insulation Tester

Combined Model

This instrument, Model P-3, combines a Hipot tester with a fault indicator and counter for continuous production use in the manufacture of insulated wire or other material. This dual unit allows the testing of two distinct types of insulation faults: pinholes and substandard insulation. By energizing the forward electrode with a suitably low potential (100 v) and the following electrode with high voltage (up to 20,000 v), separate indications and counts for both pinholes and substandard insulation are obtained. Thin spots, contaminated insulating material or lack of centering of a wire within plastic insulation are some of the faults that are detected.

Peschel Electronics, Inc., Dept. ED, 15 Garden St., New Rochelle, N.Y.

CIRCLE 150 ON READER-SERVICE CARD FOR MORE INFORMATION

drift zero

One of the remarkable achievements of the revolutionary GPL Doppler air navigation systems is that they reduce drift to zero. We believe that GPL can reduce your personal "career drift" to zero, too.

GPL was formed in 1945 with a nucleus of 25 engineers from MIT's famed wartime Radiation Laboratory. Today GPL employs 2,000 people, most of whom work at our beautiful 69-acre estate at Pleasantville, just 35 miles north of New York City.

With two new engineering buildings under construction, a hefty backlog of orders, recognized leadership in several fields of electronics and research going on into many new ones, the future of GPL is extremely bright.

Besides the top pay and beautiful suburban environment, GPL engineers enjoy many other benefits: a professional atmosphere, small working groups that ensure individual recognition, and the finest facilities that money can buy. They benefit, too, from GPL membership in the nationwide GPE Group.

If you are interested in a "drift-free" career – a career that keeps moving ahead along a straight line of accomplishment–why not call or write to us today?

We have openings in the following categories:

re: DOPPLER & INERTIAL Air Navigation and Guidance Systems

Radar:
Project Engineering, Research, Design
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Research • Design • Development • Applications
Systems Analysis • Systems Test
Mechanical Design • Test Engineering
Microwave Techniques • Servos
Magnetic Amplifiers • IF Amplifiers
Pulse Circuitry • Transistorization

For interviews call Mr. Richard D. Hoffman,
ROgers 9-5000 (ext. 435)
or write:

GPL A SUBSIDIARY OF GPE

General Precision Laboratory Incorporated

63 Bedford Road, Pleasantville, New York

For Further Information, Please Contact Advertiser Directly

New Products

Wave Generator

Versatile Low-Frequency

Thirty-seven basic output forms are available from this Type LF-51 generator, including sine, triangular, sawtooth, pulse, square and trapezoidal waves, as well as ramp and step functions. Sine waves may be generated at 500 cps to 0.0005 cps, corresponding to periods of 2 msec to 33 minutes. Pulse duration is variable from 1 msec to 1000 sec, with rise time (10 per cent to 90 per cent) less than 5 μsec. Ramp functions are linear to within 1 per cent over the range of 1 msec to 16 minutes.

Output may be continuously varied from 150 v to 100 μv, peak to peak, in six ranges. Accuracy of indicated output amplitude is ±3 per cent of full scale on any range, for load currents not exceeding 5 ma. The output may be with respect to ground, or may be biased to any level within ±100 v of ground. The Type LF-51 is capable of withstanding 40 g shocks in any direction.

British Industries Corp., Dept. ED, 80 Shore Rd., Port Washington, N.Y.

CIRCLE 152 ON READER-SERVICE CARD FOR MORE INFORMATION

28 V D-C Power

Mag Amp Regulated

This power supply is designed for operating relays, motors, filaments and control equipment. Unit is light weight, and incorporates magnetic-amplifier circuitry for dependability. Regulation for 28 v d-c/5 amp. output is ±.25 v d-c change to NL to FL. For line voltage change of 105-125 v ac (at 28 v d-c/5 amp output), regulation is ±.25 v d-c change in output. Ripple and internal noise are below 2.5 v ac rms.

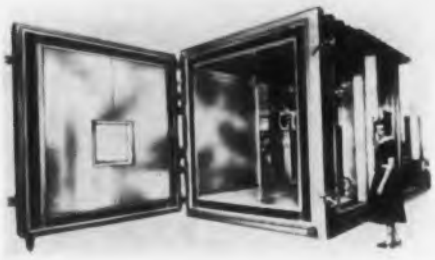
Designated Model .28— 5 mxr, the unit is compactly built, measuring 12-1/2 in. long and 4 in. wide. Height above deck is 5 in.— below deck: 2-1/8 in. The sub-chassis mounting makes it suitable for laboratory and production testing, or for inclusion in original equipment.

Dressen-Barnes Corp., Dept. ED, 250 N. Vinedo Ave., Pasadena, Calif.

CIRCLE 153 ON READER-SERVICE CARD FOR MORE INFORMATION

Test Chamber

For Flight Testing



This walk-in test chamber for temperature, altitude and humidity provides flexibility for simulated flight testing of electronic components. The free work space of 7 x 10 x 8 ft high may be partitioned with specially designed removable panels to make three separate test compartments all with separate temperature controls. It has special manifolding which maintains altitude simulation within the chamber at the same time the chilled air is being introduced.

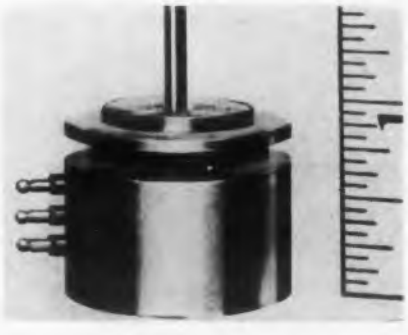
The test facility has a temperature range of from −100 to +300 F, relative humidity from 20 to 100 per cent over a dry bulb range of +35 to +185 F, and altitude from sea level to 100,000 ft or more.

American Research Corp., Dept. ED, Farmington, Conn.

CIRCLE 156 ON READER-SERVICE CARD FOR MORE INFORMATION

Rotary Transducer

± 0.5 Per Cent Linearity



Different models of this line of rotary transducers for sensing angular displacement exhibit linearity of ±0.5 per cent or better through 60 deg of best linear range, and of ±1 per cent over entire 120 deg linear range. Their design provides comparative insensitivity to ambient temperature changes. Miniature precision ball bearings support shaft, otherwise there are no mechanical contacts between rotor assembly and bridge housing to produce friction or electrical noise. Sensitivity is 1 mv/v/deg rotation, reproducibility is better than 0.1 per cent and resolution is limited only by external circuitry. Operates in ambient temperatures from −700 to 180 F.

Crescent Engineering & Research Co., Dept. ED, 5440 No. Peck Rd., El Monte, Calif.

CIRCLE 157 ON READER-SERVICE CARD FOR MORE INFORMATION

military test equipment

TS-419
SIGNAL GENERATOR

900 to 2100 mc

AN/USM-26
FREQUENCY COUNTER

10 cps to 220 mc

FREQUENCY METER
TS-186D/UP

100 to 10,000 mc

northeastern Manchester — **engineering** New Hampshire

CIRCLE 158 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Variable Delay Line
± 1 Per Cent

Time delay accuracy of ±1 per cent at any point, motor-driven for automatic time tracking, rise time less than 4 per cent, and negligible overshoot, are features of the Type 606 Series. Time delay per step is 1/120 of the total time delay; attenuation is about 4-6 db maximum. There are 14 different models available with maximum time delay 1.2 μsec to 1200 μsec; impedance varies from 75 ohms to 1000 ohms.

Advance Electronics Lab., Inc., Dept. ED, 249-259 Terhune Ave., Passaic, N.J.

CIRCLE 160 ON READER-SERVICE CARD FOR MORE INFORMATION

Gearmotor
Planetary Type

Model PG5B81RP65 is a 30 v dc permanent magnet governed planetary type gearmotor. It has 1.2 rpm output speed ±1 per cent with an output torque of 16 oz-in., and requires 1 amp of current at 30 v dc. The governor is applied in the armature circuit without use of slip rings or brushes. The motor measures 1-1/4 in. in diam by 3 in. in L and weighs 7 oz.

Western Gear Corp., Dept. ED, Electro Products Div., P.O. Box 182, Lynwood, Calif.

CIRCLE 161 ON READER-SERVICE CARD FOR MORE INFORMATION

Digital Ohmmeters
Modular

These E-I Digital Ohmmeters feature modular construction. Both 4- and 5-digit models are made up of two modules: a Universal Power Module and a Resistance Switch Module. The switch module contains all three arms of a full Wheatstone bridge as well as the visual read-out. The Universal Power

Module supplies all power and reference voltages for the resistance switch modules and for other modules which might be combined with the Resistance Switch Module. The ohmmeter provides a range from 10 milliohms to 10 megohms. Ranging is automatic; however, controlling contacts are available at the rear panel for programmed ranging.

Electro Instruments, Inc., Dept. ED, 3794 Rosecrans, San Diego, Calif.

CIRCLE 162 ON READER-SERVICE CARD FOR MORE INFORMATION

High-Speed Plotter

Four Modes

The Type S Electroplotter offers users of general purpose computers four degrees of freedom in presenting output data in graphic form. The simplest output of the machine is a two-dimensional X-Y point-to-point plot. The more complex displays include: the presentation of digital information at demandable positions over the plotting area; the plotting of discrete points at any position, flagged by a line of digital and symbolic information; the rotation of the entire printing mechanism forming the plotted point, or any simultaneous combination of the three. The machine operates at rates of between 70 and 100 complete displays per minute.

Benson-Lehner Corp., Dept. ED, 11930 W. Olympic Blvd., Los Angeles 64, Calif.

CIRCLE 163 ON READER-SERVICE CARD FOR MORE INFORMATION

Bobbins

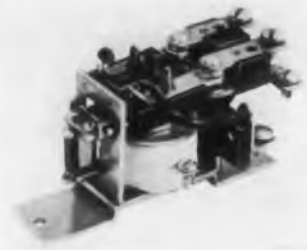
Stock Items

A complete line consists of nylon bobbins for ferrite pot and cup core applications. These bobbins are of thin wall construction and held to close tolerances. They will fit most of the popular cores as supplied by ferrite core manufacturers. These parts are available for delivery from stock without mold cost.

American Molded Products, Dept. ED, 2727 W. Chicago Ave., Chicago 22, Ill.

CIRCLE 164 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products



Industrial Relay
General Purpose

This general purpose relay incorporates such design features as interchangeable coils and a removable multiposition base. Contacts rated at 20 amp, 115 v 60 cy ac or 24 v dc, are single and double pole, single and double throw. Mounting arrangements are provided for auxiliary spdt contacts if desired. The relay is 2-7/16 in. high with a base measuring 1 x 3-7/8 in. Choice of mounting base (metal strap or bakelite), choice of coil voltages (ac, 6 through 230 v, or dc, 6 through 115 v), and choice of terminal connections are offered.

Wheelock Signals, Inc., Dept. ED, Long Branch, N.J.

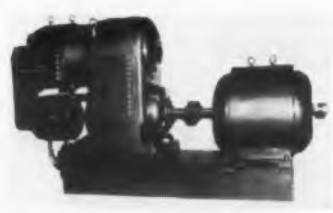
CIRCLE 167 ON READER-SERVICE CARD FOR MORE INFORMATION

Signal Generator
S Band

Model SG-153 covers the frequency range from 1800 to 4000 mc in one band. Low standing wave ratio of the output system and small residual leakage make possible overall measurements on high gain receivers at the microvolt level, the output being continuously variable between 0.2 and 200,000 μv. Low noise operation permits measurements of noise figures, image rejection, bandwidth, filter-characteristics, attenuation, etc. It can be pulse or frequency modulated.

Transistron, Inc., Division of Van Norman Industries, Dept. ED, 186 Granite St., Manchester, N.H.

CIRCLE 168 ON READER-SERVICE CARD FOR MORE INFORMATION



Motor Generator
Variable Frequency

A vari-drive motor is used to drive a low distortion synchronous alternator to deliver continuously variable frequency over the range of 300 to 500

Using Thermistors

Edited by
FENWAL ELECTRONICS

Here's more news on thermistors — the tiny, highly temperature-sensitive, semiconductors that are being used in more and more applications in all types of industry.

Let's look at just three ways thermistors are now being used . . . Time Delay, Remote Control and Switching.

A thermistor placed with a variable resistor in series with a battery and a relay (Fig. 1) makes an excellent time delay relay. The high resistance of the thermistor limits the current flow when the switch is closed. The delay time may be increased or decreased by increasing or decreasing the series resistance.

By selecting a thermistor with the same constant as the tube filament it will be in series with, you can keep the current constant during the initial warm-up and prevent an initial current surge.

Bead thermistors are available with attached heaters and mounted in a vacuum bulb. (Fig. 2) The thermistors' resistance is reduced when power is applied to the heater. When placed in the input of a vacuum tube amplifier these thermistors make smooth, noiseless remote gain controls, because there are no moving parts or controls in the grid circuit.

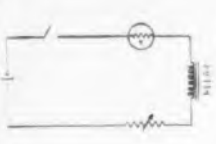


FIG. 1

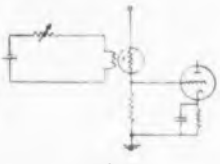


FIG. 2

When several low voltage light bulbs are connected in series with a suitable thermistor connected in parallel with each unit, (Fig. 3) very little current will pass through the thermistors. Thermistors are not appreciably heated by the small voltage drop across the bulb. If one bulb burns out, the other bulbs remain lighted — the thermistor continues to carry the load of the extinguished bulb. When the bulb is replaced it takes the current from the thermistor. The thermistor then cools off and returns to its idle condition of high resistance and low current.

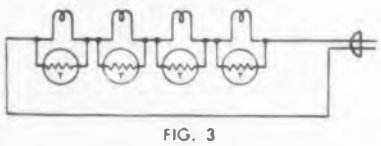


FIG. 3

Engineers: these and other thermistor applications are discussed in 12-page catalog EMC-1. Write for your copy to FENWAL ELECTRONICS, INC., 35 Mellen St., Framingham, Massachusetts.

Fenwal Electronics

Makers of Precision Thermistors

CIRCLE 170 ON READER-SERVICE CARD

cycles. The generator is rated 10 kw, 0.8 pf, 120/208 v over the entire frequency range. Voltage is held to a tolerance of ±2 per cent and both frequency and voltage are controlled from remote panel. Frequency regulation is less than 5 per cent and harmonic distortion is less than 1 per cent. Various modifications are available.

William I. Horlick Co., Inc., Dept. ED, 266 Summer St., Boston 10, Mass.

CIRCLE 171 ON READER-SERVICE CARD FOR MORE INFORMATION

Printed Circuit Terminals

Snap-In Types

These terminals, designed for printed circuits, snap into place. They have been designated C-42335 and C-42263. The second has been given the further designation Amp Edge. Terminal C-42335 is made of brass with tin finish, is designed to snap into a hole 0.072 in. dia. has an inside diameter of 0.10 in. and an overall length of 0.565 in. Terminal C-42663 comes in brass, or is tin plated and measures 0.490 in. overall length, 0.075 in. inside dia.

Aircraft-Marine Products, Inc., Dept. ED, Harrisburg, Pa.

CIRCLE 172 ON READER-SERVICE CARD FOR MORE INFORMATION

Synchro

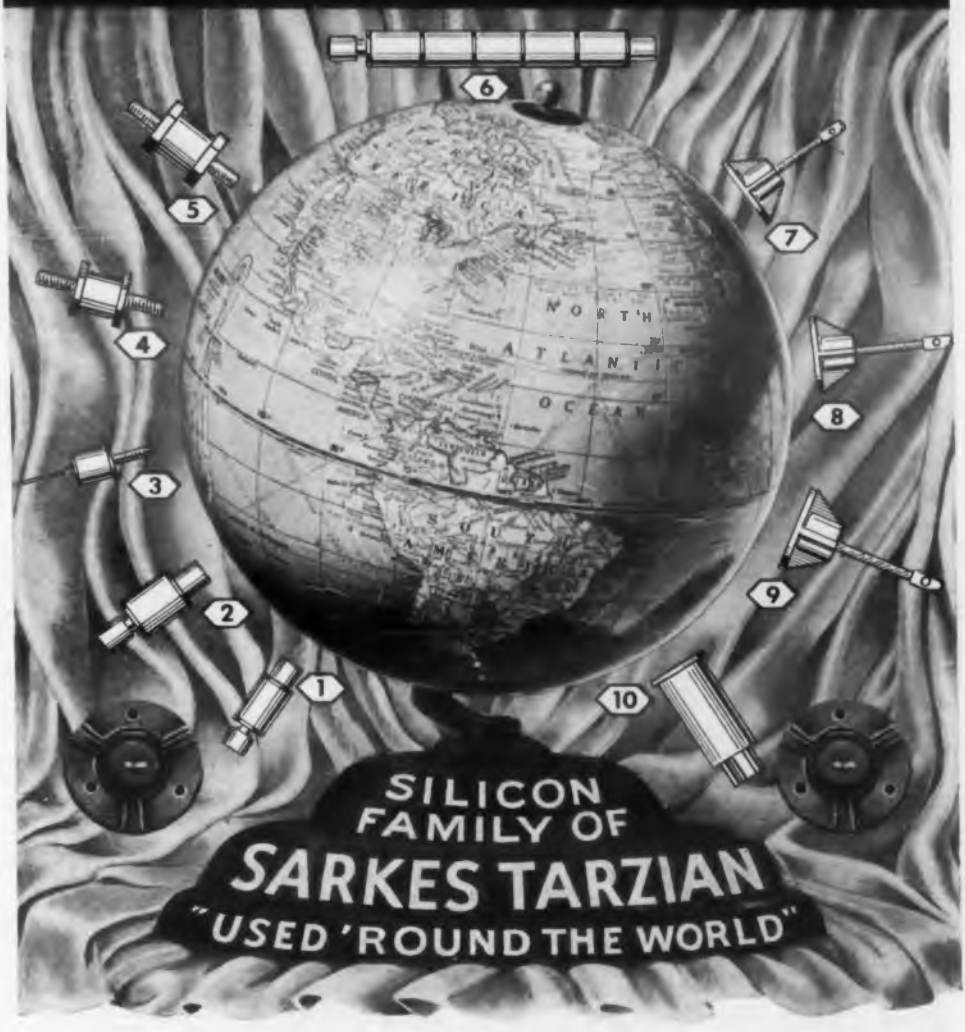
—65 to +400 F

A new synchro with a —65 to +400 F operating temperature range has a 250 hr life at 400 F. An unusual lubrication method and a special alloy for electrical connections are being used to successfully withstand the extreme heat. Type 11-4133-01 is a size 11 torque transmitter synchro with 115 V 400 cy input. Accuracy is ±15 in., null voltage 175 mv, stator output 90 v and phase shift 6.5. Impedances are Zro = 315 + J1590, Zso = 290 + J773 and Zrss = 520 + J286. Designed for extremely high temperature applications.

John Oster Mfg. Co., Dept. ED, Avionic Div., Racine, Wis.

CIRCLE 173 ON READER-SERVICE CARD FOR MORE INFORMATION

what's YOUR POWER need?



1. M series-100 Volt to 400 Volt PIV - .5 Amp. DC
2. L and LF series-100 Volt to 400 Volt PIV - 1.5 to 5 Amps. DC
3. N series - 50 Volt to 400 Volt PIV - .5 to 1 Amp. DC
4. P series - 50 Volt to 400 Volt PIV - 1.5 to 5 Amps. DC
5. Q series - 50 Volt to 400 Volt PIV - 7.5 to 15 Amps. DC
6. SM series - 800 Volt to 2800 Volt PIV - .325 to .450 Amp. DC
7. R series - 50 Volt to 200 Volt PIV - 20 Amps. DC
8. S series - 50 Volt to 200 Volt PIV - 35 Amps. DC
9. V series - 50 Volt to 200 Volt PIV - 100 Amps. DC
10. 1N1150 Full Wave Silicon Tube Replacement Rectifier (4 pin base) 1600 Volt PIV - .75 Amp. DC (Replaces types 80, 82, 83V and 5Z3)

Write for complete information

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RECTIFIER DIVISION

Address: Dept. C-3

415 N. COLLEGE AVE., BLOOMINGTON, IND.

IN CANADA: 700 WESTON RD., TORONTO 9, TEL. ROGERS 2-7535 EXPORT: AD AURIEMA, INC., NEW YORK CITY

CIRCLE 174 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Portable Oscilloscope

Weighs 27 lb

This portable 3-in. CRT oscilloscope has a sensitivity of 22 d-c mv per in. It weighs 27 lb and measures 5 x 19 x 11-1/8 in.

With a 2.5 kv accelerating potential on the Type 3WP CRT, a singularly bright trace can be obtained. The instrument has identical direct coupled X and Y amplifier and amplitude calibration on both channels, driven and automatic sweeps.

Allen B. Du Mont Labs., Inc., Dept. ED, 750 Bloomfield Ave., Clifton, N.J.

CIRCLE 176 ON READER-SERVICE CARD FOR MORE INFORMATION

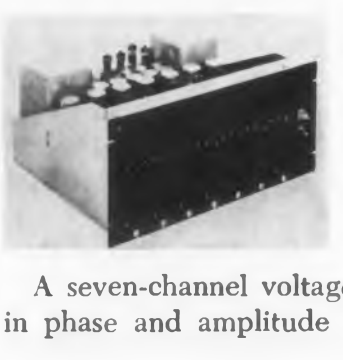
Epoxy Insulators

For High Voltage

These epoxy high voltage cable terminations, bushings and stand-off insulators are designed to meet specific space, mounting, and operating conditions. The cable to air and cable to oil terminations shown are rated at 150 kv dc with a flash over of more than 185 kv rms (260 kv peak). The stand-off insulators, which are 15, 10, 7-1/2, and 5-1/2 in. long are rated at 50, 40, 30 and 20 kv rms in air and 100, 90, 75, and 60 kv rms in oil with a flash over of at least 2-1/2 times rated voltage. Special bases and caps can be provided to allow for use at higher voltages and to care for special mounting requirements.

Components for Research, Inc., Dept. ED, 937 Industrial Rd., Palo Alto, Calif.

CIRCLE 177 ON READER-SERVICE CARD FOR MORE INFORMATION



Linear AC Amplifier

Used with Transducers

A seven-channel voltage amplifier system, linear in phase and amplitude characteristics from 2 to

100,000 cps, is being used in recording transducer signals on standard types of wideband magnetic tape equipment. Each channel may be set to any of eleven steps of voltage gain from 1.00 to 100, the changes being entirely in the feedback networks without degradation of the signal-to-noise ratio by excessive attenuation of the input signal. Capability of driving capacitive loads with good transient response makes possible the location of the recorders at a distance from the amplifiers. The system is self-contained, with its own power supply requiring a 117 v 60 cps line.

Dynamics Instrumentation Co., Dept. ED, Div. of Alberhill Corp., 1118 Mission St., South Pasadena, Calif.

CIRCLE 180 ON READER-SERVICE CARD FOR MORE INFORMATION

Trimmer Capacitors
Wide-Range

Miniaturization and low temperature coefficients, combined with mechanical stability and high ratios of maximum to minimum capacities, are featured in these trimmer capacitors. The company's four new models, for example, have the following capacity ranges: 0.5 to 5 μμf, 0.6 to 14 μμf, 0.8 to 35 μμf and 2 to 75 μμf. Air dielectric, gold, silver, and rhodium plating, and Pyrex insulation result in high Q at high frequencies. Stability is provided by two sets of spring fingers which tightly grip the rotor assembly.

Johanson Mfg. Corp., Dept. ED, Boonton, N.J.

CIRCLE 181 ON READER-SERVICE CARD FOR MORE INFORMATION

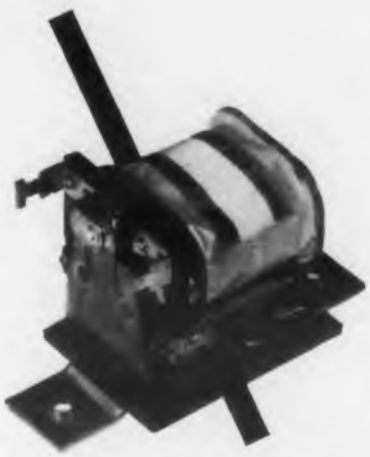
Control Amplifier
Miniature Module

This diminutive transistorized control amplifier has a life expectancy of 10,000 or more, with ripple less than 50 mv from peak to peak, operating temperatures of −65 to +125 C, and is adaptable to voltages of ±50 to ±1000. Its regulation is ±1 per cent, with circuit gain of 60 to 80 db.

Packard Bell Electronics Corp., Dept. ED, 12333 W. Olympic Blvd., Los Angeles 64, Calif.

CIRCLE 182 ON READER-SERVICE CARD FOR MORE INFORMATION

as AC magnet relays go . . .



. . . the Sigma Series 41 is surprisingly sensitive, and even remarkably quiet. And like other shaded pole types, it is also inexpensive and reasonably indestructible. To wit, in order, 0.06 to 1.0 volt-ampere; useful in electric blanket controls; $3.50-$9.45 in quantities 1-19, after which quantity discounts apply; undamaged by shocks and constant acceleration up to 100 g, and contact life of many million operations in normal use and with adequate arc-suppression.

Such a combination of characteristics can be quite useful, as illustrated (illus.) by the Sigma CdS Photorelay, Model 1. Here a broad area cadmium sulfide cell has been connected to the coil of a 41, with the SPDT connections conveniently brought out to a 5-pin base, on which a 1½" square aluminum dust cover sits snugly. In "light—no light" applications, such as light beam interruptions, 3 amp. (resistive) 120 VAC loads can thus be switched quite handily. Much of the credit (in fact, all) for no tubes, rectifiers, buzz, etc., belongs to the 41. This paragraph was not meant to sell the Photorelay, but if it has, it should be stated that the price is $12.00.

An application of the above application is also presented, as additional support for the AC versions of the 41, in the new Nitelighter® lighting control (a product of our wholly owned parent company**). Aimed toward the daylight, and connected to a light (300 watts max.) of your choice (and plugged into a wall outlet), the Nitelighter can protect your home, your shins on otherwise dark stairs, the production rate of your business (if you sell eggs), and generally you against nyctaphobia*. Logically enough, this is also for sale** for $15.95.

There are many sensible jobs the 41 can do, some of them with exculsive merit. Bulletin on request.

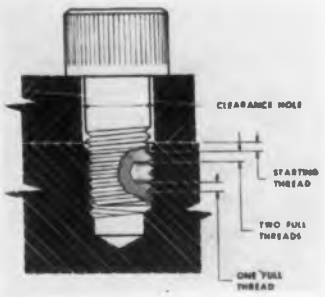
*Authority for origin doubtful.
**The Fisher-Pierce Co., Inc., 91 Pearl St., So. Braintree 85, Mass.

SIGMA

SIGMA INSTRUMENTS, INC.
91 Pearl St., South Braintree 85, Mass.

CIRCLE 183 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products



Socket Head Screws

Self-Locking

Recommended practices for preparing tapped holes for these socket head screws fitted with Nylok self-locking inserts are shown in this drawing. A 90-deg countersink should be used to make the starting thread approximately 1/32 in. larger than the major thread diameter. The maximum tensile strength of the screw is obtained when the locking pellet is at least two full threads beyond the starting thread of the tapped hole when the screw is fully installed. The line of self-locking socket head screws come in sizes No. 6 and larger.

Standard Pressed Steel Co., Dept. ED, Jenkintown, Pa.

CIRCLE 185 ON READER-SERVICE CARD FOR MORE INFORMATION

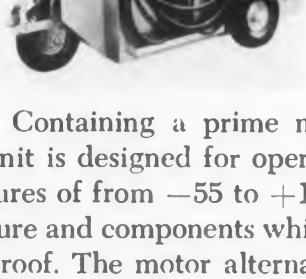
Cable Harness

Easily Wrapped

Known as Spiral Wrap, this product is designed to simplify the harnessing of loose wires into neat cables. Made from polyethylene tubing in 1/4- and 3/8-in. diam, and cut into a spiral pattern, it will wrap easily around loose wires to make cables in any diameter up to 2 in. Wires may be pulled out at any desired position. It is available in white, red, and blue for color coding.

Illumitronic Engineering, Dept. ED, 680 E. Taylor, Sunnyvale, Calif.

CIRCLE 186 ON READER-SERVICE CARD FOR MORE INFORMATION



Motor Alternator

Trailer Mounted

Containing a prime mover and alternator, this unit is designed for operation in ambient temperatures of from −55 to +130 F. It features an enclosure and components which are sand, dust and dripproof. The motor alternator set, Model EPM-1470,

is applicable to the areas of launching site or flight line operational servicing and repair of systems. Manufacturers and users of industrial routers and grinders utilizing high speed induction motors, and manufacturers of industrial and medical X-ray equipment are among the potential users.

American Electronics, Inc., Dept. ED, Electric Machinery and Equipment Div., 655 W. Washington Blvd., Los Angeles 15, Calif.

CIRCLE 189 ON READER-SERVICE CARD FOR MORE INFORMATION

Contact Screw

Longer Life

Essentially a fine silver or silver alloy core, this screw is silver-brazed-bonded to a high strength metal alloy shell which is threaded. The precious metal core is continuously bonded to the threaded shell and provides the optimum heat transfer path for dissipation of heat developed by the contact arcing. Because the contact runs cooler, pitting and wear is reduced and longer contact life results. Another advantage is that no oxides can develop between the precious metal and the outer shell, assuring positive and permanent electrical conductivity between the precious metal and the outer shell. Loosening of the precious metal is prevented.

George Ulanet Co., Dept. ED, 413 Market St., Newark, N.J.

CIRCLE 190 ON READER-SERVICE CARD FOR MORE INFORMATION

Thermocouple Welder

Portable

A miniature resistance welder has been developed for use primarily in welding thermocouple junctions and leads and for use as a tacking welder to secure thermocouples, straingages, thermistors, etc., to large bodies.

The welding head in the unit can be used as a small low inertia foot-operated bench welder with adjustable pressure of 1 to 10 lb indicated on a calibrated scale, or it can be removed from the case and used as a single electrode tacking tool with the same pressure adjustment.

Ewald Instruments, Dept. ED, Kent, Conn.

CIRCLE 191 ON READER-SERVICE CARD FOR MORE INFORMATION

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This is Honeywell in Minneapolis . . . an ideal atmosphere for the engineering mind. At work; outstanding technical facilities plus the opportunity to work on today's most advanced electronic projects, a chance to work in a small group, guide your own project, get the recognition you deserve.

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IMC's new 3800 Frame series is the ultimate in diversity for motors of this type. These AC motors, available for induction, torque or hysteresis synchronous applications, are designed to all commercial and military specifications, with built-in resistance to humidity, vibration, shock, radio noise and salt spray. The unit can be supplied as self cooled with internal fan.

SPECIFICATIONS—3800 FRAME AC MOTORS

INPUT VOLTAGE: 26 to 230 volts AC 1, 2 and 3 phase

INPUT FREQUENCY: 25 to 400 cycles

NUMBER OF POLES: 2, 4, 6, 8 and 12 poles

OUTPUT POWER: Induction motors—to 1 hp
Torque motors—10 to 200 oz. in. stall torque
Hysteresis synchronous motors—1/200 to ¼ hp
(Can be wound for single, dual or three speed)

AMBIENT TEMPERATURE: −55° to +71° C. standard
−55° to +150° C. available

BEARINGS: Ball or sleeve

MOUNTING: Round or square flange and/or base

SHAFT: Single or double extension—max. dia.—.4997

WEIGHT: 8-11 lbs.

The 3800 Series can also be supplied for use as fan and blower motors and permanent magnet generators. Request Bulletin 38 from

Induction Motors Corp.

570 Main St., Westbury, L. I., N. Y. Phone EDgewood 4-7070

CIRCLE 192 ON READER-SERVICE CARD FOR MORE INFORMATION

New Products

Ring-Type Cores

Resin-Insulated

This resin-insulated ring-type core made in all gauges from 1 to 12 mils thick is used for toroidal designs ranging in size from small blocking-oscillator pulse transformers through large power units. Windings can be placed directly on the core, eliminating the need either to tape the core or to encase it in a plastic or aluminum box. The resin coating is continuous and smooth. Corners are rounded to eliminate any possibility of shorting wire to core. The coating does not impair magnetic properties of the core and withstands a voltage to ground of 2500 v.

Westinghouse Electric Corp., Dept. ED, P.O. Box 2099, Pittsburgh 30, Pa.

CIRCLE 193 ON READER-SERVICE CARD FOR MORE INFORMATION

Potentiometer

Sensitive Measurements

The accuracy of this instrument, designated Model HF2, as calibrated is 0.05 mv plus one-half a scale division of 0.1 mv. Two rheostats are provided for coarse and fine adjustment of the potentiometer current. The galvanometer is of the torque suspension type which does not require locking in transit. Its high sensitivity, 0.67 μa/mm., and low resistance, 15 ohms, makes available the full sensitivity of the instrument when measuring potential from low resistant sources such as thermocouples.

Williamson Development Co. Inc., Dept. ED, 317 Main St., West Concord, Mass.

CIRCLE 194 ON READER-SERVICE CARD FOR MORE INFORMATION

Constant Delay Line

No Distortion

The type S10A2-8 lumped constant delay line has a rise time of 0.09 μsec with a delay of 10.0 μsec. The line has an impedance of 200 ohms and is tapped every 0.5 μsec with an accuracy of ±0.02

μsec. Additional taps may be provided as desired. The line is capable of retaining a flat top on pulses as narrow as 0.2 μsec. The operating temperature range is 0 to +55 C with a coefficient of 50 ppm per deg C. Operation from −55 to +125 C may be provided by special order.

Orbitran Co., Dept. ED, Lakeside, Calif.

CIRCLE 305 ON READER-SERVICE CARD FOR MORE INFORMATION

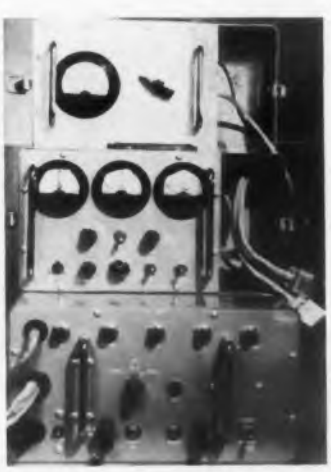
Two-Channel Scope

15 Mc Range

Equipped with vertical amplifiers capable of handling any frequency from dc to 15 mc, the Model K-215 2-channel oscilloscope provides for accurate triggering, viewing or recording of simultaneous phenomena. Features include 10 kv acceleration potential and transistorized multi-vibrator providing 1 kc square wave calibrator. Frequency range of horizontal amplifiers is dc to 2 mc with deflection sensitivity of 1 v dc per cm. Two variable sweep generators have expanded ranges from 0.1 μsec per cm to 1 sec per cm. Time base is separate or common as selected by front panel control. Triggering may be either internal or external.

Electronic Tube Corp., Dept. ED, 1200 E. Mermaid Lane, Philadelphia 18, Pa.

CIRCLE 306 ON READER-SERVICE CARD FOR MORE INFORMATION



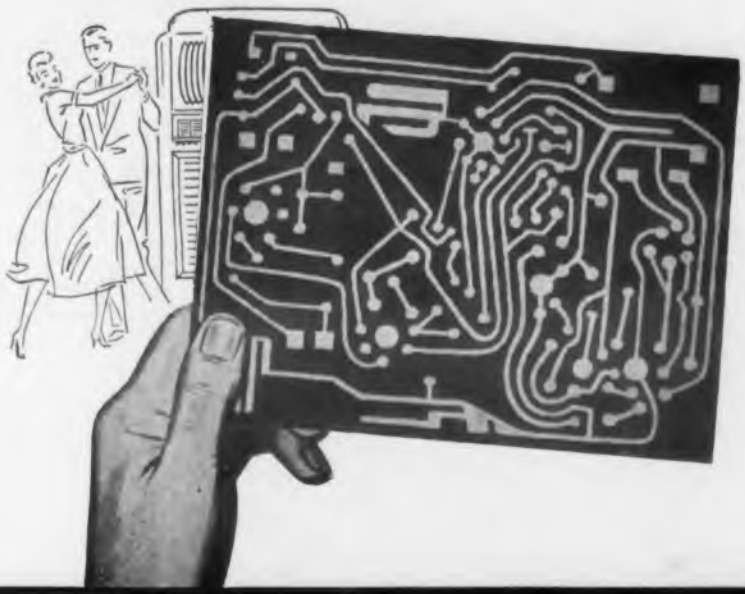
Test Set

For Airlines

The Model 604 Field Test Set for commercial airlines provides a systematic means of completely checking the operation of the airplane's communication set. It is designed in three units to match those of the radio set and tests out the remote system, the frequency generator or monitor, and the mechanical tuning system. A complete check can be made in approximately one hour.

Cal-Tronics Corp., Dept. ED, 11307 Hindry Ave., Los Angeles 45, Calif.

CIRCLE 307 ON READER-SERVICE CARD FOR MORE INFORMATION



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and makes them better

C-D's Printed Wiring Division renders the most complete printed circuit fabrication service possible. Equipment, processing techniques and engineering skills can produce any printed circuit design in long production or experimental pilot runs.

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CIRCLE 572 ON READER-SERVICE CARD FOR MORE INFORMATION

New Literature

Frequency Meter and Recorder 198

The Model 7341B frequency indicator and printing recorder and the Model 7550B frequency, period, and time interval meter are each the subject of a single-page data sheet. Both sheets provide an illustration, a description covering operation and design, and a detailed list of specifications. Electro-Pulse, Inc., 11861 Teale St., Culver City, Calif.

Insulated Wire 199

Two one-page data sheets have been issued to describe the Series 120 lead wire and the Series 200 hook-up wire. Both pages offer an illustration, a description, a table of available sizes and a list of performance requirements. Philadelphia Insulated Wire Co., 200 N. 3rd St., Philadelphia 6, Pa.

Pulse Forming Network Report 200

A recently completed high-voltage pulse forming network reliability report has been published in an eight-page booklet. Presented verbatim are the data and results of a 10,000 hr reliability report on a production unit. Illustrated with photographs, the booklet also contains tables showing electrical test results and pulse measurements. AMP Inc., Harrisburg 18, Pa.

Piezoelectric Transducers 201

"Instructions for the Application of Piezoelectric Transducers" is the title of a recent 12-page manual. Using charts and curves to indicate characteristics and limitations, the illustrated booklet outlines general applications. Topics covered include high frequency response, basic design, low frequency response and qualities desirable in associated instrumentation. Endevco Corp., 161 E. California St., Pasadena, Calif.

Silicon Iron Magnetic Tapes 202

Four pages of descriptive data on silicon iron magnetic tapes are presented in Bulletin DMF-4. Given is information on applications, sizes, weights, tolerances, insulation, fabrications, mechanical and physical properties, magnetic properties and core losses. Thomas & Skinner, Inc., East 23rd St., Indianapolis, Ind.

Clad Metals 205

Technical Data Bulletin CM-901 contains 4 illustrated pages on clad metals, contact materials, and contact assemblies. Its clad metal finder chart shows at a glance the major types available, their design and engineering functions, and their applications. American Silver Co., 36-07 Prince St., Flushing 54, N.Y.

Amplifiers 206

400 and 60 cps magnetic amplifier data and specifications are given in 16 page product catalog just released.

The illustrated brochure gives a complete description and the features of each item along with the average characteristics. Also included are the mechanical specifications of each model. Litton Industries, Maryland Div., (Formerly Ahrendt Instru. Co.) 4910 Calvert Road, College Pk, Md.

Identicharts 207

A two color, four page folder illustrating and describing identicharts that record on strip charts from a remote point the exact time or sequence conditions occurring during process control and test work has recently been released. The folder also illustrates and describes related equipment such as a card printer for a strip mill gauge and accessory equipment for integrators.

The models are described and illustrated together with a sample of the identifying marks. The job of interpreting the charts is made easier by this method and it eliminates the need for someone to watch the charts and make identification marks. Royson Engineering, Hatboro, Pa.

Humidity Chamber 208

Low Cost vapor-temp recording controlling humidity chamber is shown in illustrated two page, two-color brochure No. 5670 just released.

Featured is a graph giving the exact per cent relative humidity available at various dry bulb temperatures and listing the Military Specifications the humidity chamber will meet. Blue M. Electric Co., 138th & Chatham, Blue Island, Ill.

Resistors 209

The full line of vitreous enameled stock resistors —both fixed and slide-wire are included in the 36 page bulletin No. 6592. A wide variety of tailor-made units, vitreous enameled resistors ranging from 5 to 500 w, and high-capacity resistors rated up to 1200 w.

The bulletin provides extensive selection data, ordering instructions, full product descriptions, photographs of representative resistors, ratings and other pertinent technical data. General Electric Co., Schenectady 5, N.Y.

SEALECTRO "PRESS-FIT"* subminiature TEFLON† TERMINALS

SO MIGHTY...

Yes, mighty! That's why Sealectro subminiature "Press-Fit" terminals are found in critical assemblies where failure just can't be tolerated — in guided missiles, radar, communications equipment, electronic computers, etc.

Simplest installation—just press-fit, that's it. No brittle materials or seals breaking down. Dielectric strength of 1000 to 2000 volts per mil. No carbonization from arc-over — lowest losses. Moisture condenses in droplets — no continuous film. Plus other amazing electrical characteristics matching the ideal ruggedness. Yes, mighty!

Unbelievably so. A dozen of these subminiature stand-offs and feed-thrus fit comfortably on a quarter. Sizes from .093" to .179" bushing dia. All due to the proper application of Teflon, the "miracle insulator", by the pioneer and specialist—SEALECTRO!

Get Your Copy! This handy "Press-Fit" Manual is yours for the asking. Likewise application engineering second to none, applied to your particular assemblies.

*Trademark of the original Teflon terminal manufacturer
†Reg. Trademark, E. I. Du Pont de Nemours & Co.

Sealectro CORPORATION
610 Fayette Avenue, Mamaroneck, N. Y.

CIRCLE 210 ON READER-SERVICE CARD FOR MORE INFORMATION

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Centralab High Alumina Ceramic

Centralab High Alumina ceramic can be fabricated in any shape, form, or size — to exacting tolerances — for applications requiring exceptional strength, greater shock- and heat-resistance.

In addition to its superior electrical characteristics, Centralab High Alumina ceramic is chemically inert and remains stable under radiation bombardments, elevated temperatures, and controlled atmospheres.

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One of America's largest manufacturers of engineered ceramics. Regardless of requirement, Centralab specialists and facilities can produce the High Alumina ceramic-component design you want.

X-2358

CIRCLE 211 ON READER-SERVICE CARD FOR MORE INFORMATION

New Literature

Tubing 212

A combined specification and price sheet on extruded tubing for shipment from stock has been released. Tubing is a Class C insulation and capable of continuous service at temperatures up to 250 deg C. Electrical properties are unchanged with temperatures from 25 to 250 deg C or frequencies of 60 cy to 100 mc. L. Frank Markel & Sons, Norristown, Pa.

Automation 213

"How Can I get more Dollars from less Space" is the title of Illustrated News No. 1 now available.

It includes information and application stories on automation, and the latest developments in work simplification techniques. Alden Systems Co., Alden Research Center, Westboro, Mass.

Fluoborates for Printed Circuits 214

Technical Bulletin TG-36431 describing improved plating techniques is available upon request. Discussed are copper fluoborates which sharply reduce the time required for the copper plating of thick, high-quality circuits, and lead-tin fluoborates which add solderability to printed circuits, using a 60 to 40 tin-lead deposit to expedite assembly. These high-purity plating solutions come in concentrated solution form, require no mixing or dissolving, give stability in bath composition and practically 100 per cent anode and cathode efficiencies. Bulletins on other metal fluoborates are also available. Allied Chemical & Dye Corp., General Chemical Div., 40 Rector St., New York 6, N.Y.

Squelch Device 215

Channel Guard tone squelch device, designed to reduce interference problems in two-way radio systems is described in Bulletin ECR 449 just released. It shows how unwanted signals and transmission may be avoided if the new device is installed in new radio systems or those already in use in the field. General Electric Communication Prod. Dept., Electronics Park, Syracuse, N.Y.

Research Service

Expanded industrial research services are described in a four-page circular. Also highlighted is research work undertaken in the field of applied magnetics. Photographs are used to show a variety of laboratory equipment. Bussey Research Labs., Inc., Bldg. 629 Greater Rockford Airport, Rockford, Ill.

Automatic Package Controls 219

Automatic package controls for the electrical measurement of chemical or mechanical functions are described in a catalog of 16 pages. Limit, cycling, pulsing and polypoint controls are some of the units specifically discussed. A number of meter relays are also covered. All instruments are illustrated with photographs and diagrams. Prices and specifications are added to the descriptive text. Tipp-Tronic, Inc., Tipp City, Ohio.

Stainless Steel Fastenings 220

Among the stainless steel fastenings listed in Catalog 56-A are knurled and drilled, cross drilled, double-end milled, and milled and drilled parts. Also shown are dowel pins, tapered and grooved parts, broached parts, captive screws, special tapered holes, milled AN bolts, headed parts and shafts. The catalog devotes a number of pages to information on short cuts in ordering; the replacement of specials with standards; the differences between thread types; standard specifications for various types of stainless steel; and AN specifications. This section also contains tables showing corrosion resistance and decimal equivalents. The booklet is illustrated with photographs and diagrams. Star Stainless Screw Co., 655 Union Blvd., Paterson 2, N.J.

Navigation Antenna 221

Standing-wave ratios and radiation pattern diagrams, and descriptions of the Type A-13B vhf navigational antenna are contained in a recent brochure. Designed for use on all types of aircraft, the A-13B incorporates two broadband antennas, one for use with VOR and runway localizer receivers, and one for use with glide-path receivers. Aircraft Radio Corp., Boonton, N.J.

Teflon Insulated Wires 222

Teflon insulated wires and cables are the subject of a recent 30-page catalog. Complete specifications and prices are presented on Teflon and silicone insulated magnet wires, lead wires, lacing cords, sleeving, tubing and shielded and jacketed miniature cables. American Super-Temperature Wires, Inc., W. Canal St., Winooski, Vt.

Transistorized Pulse Programming 223

The technical features of transistorized pulse programming equipment are discussed in a recent brochure. Descriptions, specifications, illustrations, and input and output waveforms are given for individual units. The booklet has an index as an aid to filing and allows for additional insertions. Navigation Computer Corp., 1621 Snyder Ave., Philadelphia 45, Pa.

4 Intercoupled servo loops

weight less than 2 lbs.*

This indicator, part of an Automatic Navigational System, contains 6 synchros, 2 motors and 2 motor generators—all Clifton Size 10 units.

These units (and 2 mechanical differentials) are built into 4 independent, intercoupled servo loops. Weight of these 4 loops plus gears and gear plates is less than 2 lbs.

The main reason for the lightness of Clifton synchros, and hence the lightness of systems built around Clifton components, is that no unnecessarily heavy materials are used in their manufacture.

When it is a question of highest accuracy with the least bulk and weight, look to CPPC rotary components.

* *If this system had been built with our latest Size 8 synchros, weight would have been brought to about 1⅓ lbs.*

Look to CPPC for Synchro Progress

CLIFTON PRECISION PRODUCTS CO., INC. cppc **Clifton Heights, Pa.**

CIRCLE 224 ON READER-SERVICE CARD FOR MORE INFORMATION

Get $10.00 plus a by-line for the time it takes you to jot down your clever design idea. Payment is made when the idea is accepted for publication. Use the "entry blank" on p 81 to submit your idea.

Modular Design with Printed Circuit Connectors

INCREASING complexity of electronic devices has necessitated the design of printed circuit modules which can be easily connected to the final equipment. A unique connector for joining these modules is described in this article. Modular design possibilities using the connector are also discussed.

The connector, manufactured by Elco Corp., Philadelphia, Pa., has a fork-like structure with four coined mating surfaces. Contact pressure is kept at an average of 1/2 lb. on each of the four contact areas of a mating contact pair. This is far above the minimum value required to avoid oxidation of the contact area under static connection. Contact resistance is .002 with a sigma of .00015. These values are practically uninfluenced by temperature, humidity, salt spray tests, aging or thousands of insertions and withdrawals.

For easy handling the contacts are mounted on plastic strips. In this way, they are perfectly positioned and are located at the correct spacing. A groove in the strip between each two contacts permits breaking at any desired length. The plastic strip is disposable after the staking operation.

Contact staking is schematically illustrated in Fig. 1. The legs of the contact are inserted through holes in the printed circuit board. A staking tool with two knife shaped cutting edges, shears approximately .009 in. off each side of the contact tail and bends this portion tight against the printed circuit pattern surrounding the hole.

Tests have shown that 45 lbs. applied to the contact axis will not loosen it from the board. The insertion or withdrawal force for two mating contacts never exceeds 1 lb. With this safety factor of 40 no loosening or strain to the solder joint is ever expected.

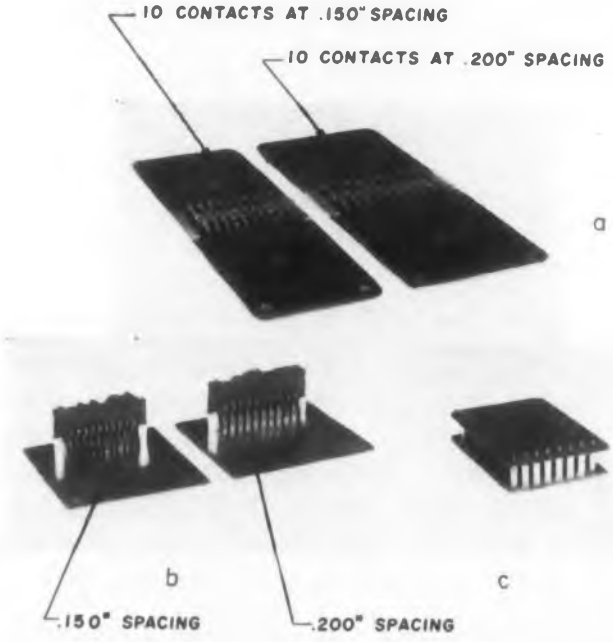

Fig. 2 Printed Circuit boards can be connected in the same plane (a), in perpendicular planes (b) and in parallel planes (c).

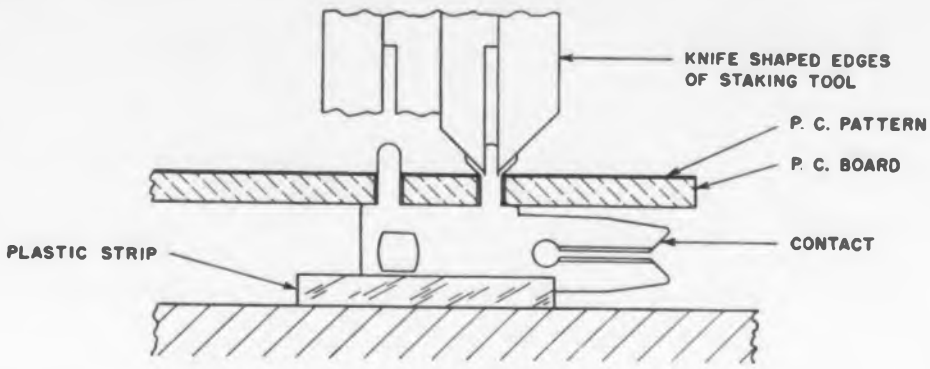

Fig. 1 Contact is mounted through holes in the printed circuit board. Tests have shown that 45 lbs. applied to the contact axis will not loosen it from the board.

Modular Construction

Connections can be made from one board to another in the same plane (Fig. 2a), in a perpendicular plane (Fig. 2b) or in a parallel plane (Fig. 2c). Any spacing and number of contacts which the circuit may require can be selected. For boards connected parallel to each other, the contacts do not necessarily have to be arranged in one row. They can be placed at any convenient location on the board, thus avoiding the necessity of carrying copper lines to the edge.

Guide brackets can be fastened to the board or omitted if other guide methods are provided in the equipment design.

A female connector is used to mate sub-module boards to the mother board.

Fig. 3 shows a computor modular assembly designed by Federal Telecommunication Laboratory, Nutley, N.J. Printed circuit wiring is on the under side of the mother board. Part of the 31 female contacts allow conventional wiring in addition to the staking to the board.

Two connectors with 31 contacts each are fastened to the top side. A sub-module board with printed circuit wiring is inserted in each connector. Five groups of ten stand-off contacts are mounted on each board. A modular coil arrangement mounted on a plate with female stand-off contacts is plugged into each of these five groups.

Variation in modular design possible with the connector are limited only by the designers imagination. He has full freedom in selecting the angle connecting two boards together, the number of contacts and the board thickness for mother and sub-module board.

H. E. Ruehlemann, Elco Corp., Philadelphia, Pa.

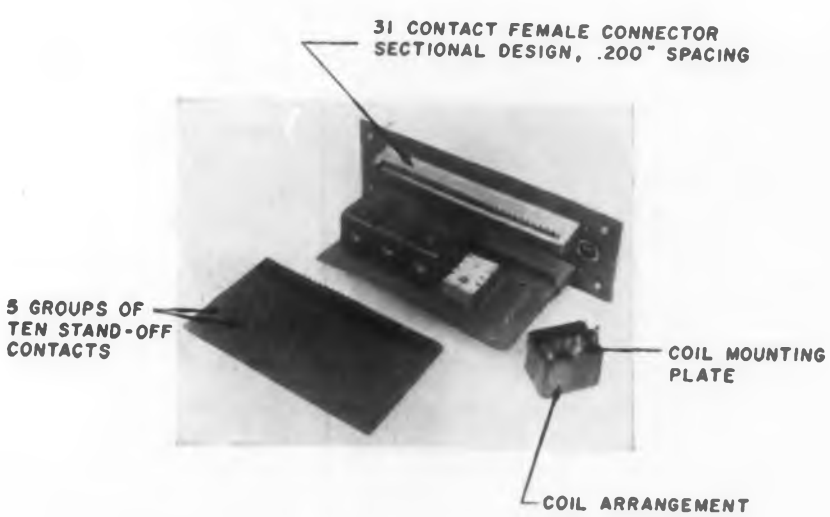

Fig. 3 Computer unit is completely modularized. Printed circuit wiring is on the under side of mother board. Component modules are mounted in the insert board.

MicroMatch

DIRECTIONAL COUPLERS

accurately monitor transmitter output

Built into major military communications and ballistic missile programs, MicroMatch Directional Couplers provide simple but precise means of continuously monitoring RF power and VSWR. Independent of frequency over a very wide range, these directional couplers are available for use at frequencies between 3 and 4000 megacycles.

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M.C. Jones

M. C. JONES ELECTRONICS CO., Inc.

BRISTOL, CONNECTICUT

CIRCLE 227 ON READER-SERVICE CARD FOR MORE INFORMATION

Ideas for Design

Dielectric Fluid

The Editors of ELECTRONIC DESIGN have noted with interest that Dow Corning's DC 550 silicone fluid exhibits high dielectric strength, low conductivity, very moderate viscosity change up to 220 C, and gives off negligible amounts of irritable volatile matter. Frequent voltage breakdown did not cause jelling of the fluid at the electrodes.

Corning's DC 550 is marketed as a heat transfer medium rather than for electrical applications. Tests made by Kouwenhoven and Knickerbocker at Johns Hopkins and Wechsler of Mica Insulator Co. on dibutyl sebacate, dibutyl phthalate, GE SF-96 silicone oil and Dow Corning 200 and 550 silicone fluids showed the DC 550 to be a superior dielectric liquid for the test purposes.

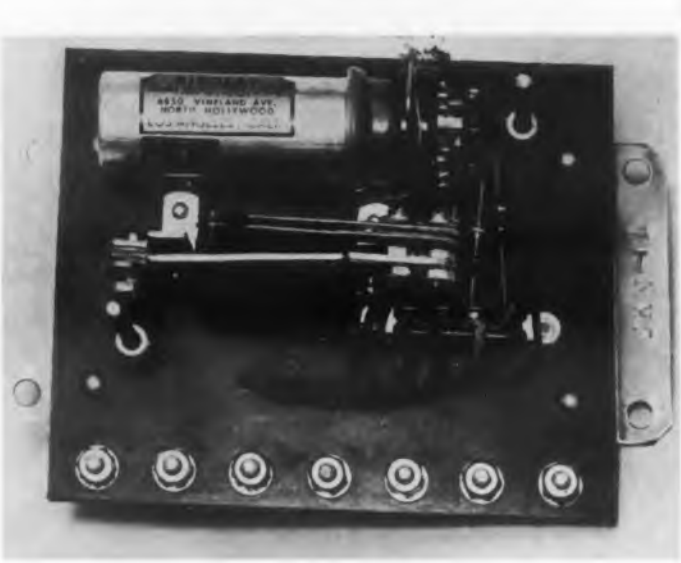
Reported in AIEE Paper CP 57-141, Thermal Stability of Laminated Thermosetting Plastics, I. Kouwenhoven, Knickerbocker & Wechsler, AIEE Winter General Meeting, January 1957.

Electrostrictive Relay

This unique non-magnetic relay operates on a principle where electrostrictive ceramic units bend to close the contact gaps when the units have a minute electric change applied.

Because of its stored-energy hold-in feature, the contacts are maintained closed for a finite time after the charging voltage is interrupted. This means that high resistance or poor circuit connections caused by dirt, moisture or oxidation at plugs or connectors will not cause an important circuit to open spontaneously.

The relay requires a very low current for operation, thus sharply increasing battery life. The manufacturer is Nicolay Manufacturing Co., 6850 Vineland, North Hollywood, Calif.



Electrostrictive Relay

Polyethylene Stabilized By Electron Bombardment

By switching from polystyrene to irradiated polyethylene for the production of hf vtvm probe tips (see photo), cracking at low temperatures due to the expansion of imbedded electronic components is avoided. Low-temperature stress cracking of polystyrene exposes the internal parts to moisture.

The tendency of conventional polyethylene to flow at high temperatures heretofore restricted its use under high ambient conditions and in applications where the probe tips were soldered directly into the electronic circuits under test. To provide a substantial increase in stability at high temperature, Hewlett-Packard Co. and Applied Radiation Corp. engineers bombarded sample polyethylene probe tips with high-speed electrons from ARCO's eight-million volt linear electron accelerator. Tests indicated good stability of the material to about 250 F with negligible effect upon tendency to crack at low temperature.

Fig. 1. Effect of irradiation on polyethylene at high temperature.

Fig. 2. Practical application of irradiated polyethylene in VTVM test probe.

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All HYCOR cased toroid coils are hermetically sealed in steel cases to MIL-T-27 specifications. Select from the six standard case styles shown above, or order to your specific requirements. Coils are wound to the exact value of inductance you specify at no extra cost. HYCOR Toroid Coils combine the advantages of high Q factors . . . excellent stability vs. temperature and current . . . shock, moisture and temperature resistance . . . self-shielding effects . . . and precision materials, components and manufacturing procedures.

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DIVISION OF INTERNATIONAL RESISTANCE COMPANY
12970 Bradley Ave., Sylmar, California

CIRCLE 231 ON READER-SERVICE CARD FOR MORE INFORMATION

Ideas for Design

Fidelity in Miniature

The trend to smaller radios has presented acute acoustical problems. Using a small speaker in a tiny space, a tinny sound results instead of true, full tones. Arvin Industries, Inc. of Chicago has overcome the problem in its new six-transistor set.

Although the vinyl-clad aluminum case is only 10-1/4 in. wide, 8-3/8 in. high, and 3-7/8 in. deep, a space nearly 6 in. square and the depth of the cabinet has been provided for the 5-1/4 in. Alnico speaker. This provides an excellent acoustical chamber of about 126 cu in.

The printed circuit wiring board has been placed lengthwise in a metal bracket at the top of the cabinet. Controls are at the ends of the cabinet near the top. The two 9-v batteries, used to power the set, are placed at each end of the case on either side of the speaker. One set of batteries will operate the radio more than 1000 hours.

Tube Fitting for Flexible Tubing

A unique fitting designed for easy installation in all types of flexible tubing requires no welding, no special adhesive and no threading. This design assures a joint as strong as the tube itself and does not reduce inside diameter or flow. The Danielson Manufacturing Co. of Danielson, Connecticut introduced this tube fitting especially for plastics and rubber tubing.

Making a tight, strong fitting is completely mechanical. The Danco fitting (elbow, tee, 90 deg. or special design) is slipped on the tube. Using the special ring holder, a non-corrosive ring is inserted into the tube. Tightening the molded nylon Danco fitting completes the operation. The joint is sealed-tight, strong, and lightweight.

Filled Nylon Thrust Washers For Vertical-Shaft Motors

Continuous operation of fan motors in a vertical position is made possible by one company through use of filled nylon thrust washers. Marco Industries of Womelsdorf, Pa. is employing these washers on shaded pole and split capacitor fractional horsepower motors for window fans, blowers, furnaces, air conditioners and other such items.

The thrust washers are placed between the rotor shaft assembly and the outside bronze oilite bearing. The steel washer formerly used created noticeable wear on the oilite bearing after two months continuous operation in a vertical position. By contrast, after two years continuous testing with the

"Nylatron" thrust washer, very little wear was observed on either the washer or bearing. The test was run on a motor having a rotor shaft weighing approximately 2 lb rotating at a speed of 1050 rpm. The washers have a low coefficient of friction and do not gall metal parts on contact. They are essentially noiseless and have a greater rigidity, higher heat distortion temperature, and better dimensional stability than standard nylon.

Manufactured by the Polymer Corp., Reading, Pa., the filled nylon washers are stamped from strip stock. The high speed stamping operation results in close tolerance parts with good concentric uniformity. The Marco Industries washer is 43/64 in. OD, 0.506 ±.003 in. ID, and 1/32 in. thick.

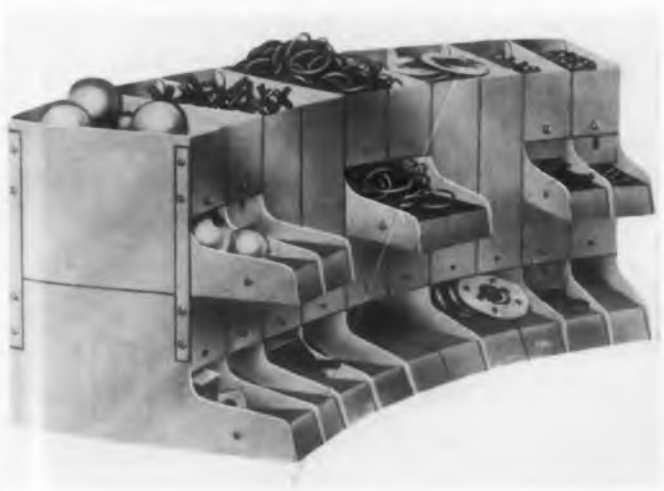
Adjustable Parts Bin Offers Flexibility

The adjustable small-parts bin shown is adaptable to most any laboratory or production requirement. Called "Speedbin", it is made of 12 standard heavy-gauge steel parts which can be arranged in a number of designs.

Manufactured by Speed Assembly Equipment Co., Box 344, Fords, N.J., this parts bin is human-engineered to the physical capacities of assembly workers. A typical installation of six bins forms an arc with a 19-in. radius in front of the operator. This conforms to natural arm movements and reduces worker fatigue.

Parts are delivered to the pick-up tray by gravity flow, which is controlled by an adjustable shutter. Parts are picked up from the protruding lip of the tray with a "hook slide grasp," easier and faster than the usual "pressure pick-up."

The bin is supplied from the rear, making it unnecessary for an operator to stop work to renew the parts supply. Each unit can be adjusted in width from a minimum of 2-1/2 in. to 15 in. Height is either 4-1/2 or 9 in. Bins can be stacked vertically as desired. Assembly is made with speed nuts which require only one twist to lock into place.



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TRANSISTORIZED FREQUENCY METER

- 10 cycle—100 KC
- ±2% accuracy

MODEL FM-241

$99.50

Note: Panel Adapter is available for mounting with TLI modular instruments.

RANGE—10 cycle—100 KC
4 ranges 100, 1K, 10K and 100K full scale
INPUT VOLTAGE—0.2 to 60V rms
INPUT IMPEDANCE—1K
ACCURACY—±2% regardless of wave shape, down to 10% duty cycle
POWER—4 penlite cells; expected life—1000 HRS.
SIZE—6½ x 5¼ x 3
WEIGHT—3 lbs.

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CIRCLE 241 ON READER-SERVICE CARD FOR MORE INFORMATION

Report Briefs

Phase Centers of E-M Horns

One important application of the electromagnetic horn is its use as the primary feed for paraboloidal reflectors. In such an application it is important to have uniform phase distribution along the reflector aperture. By the geometry of the reflector it is required that the feed is a point source located at the focus. It is obvious that an electromagnetic horn is not a point source, but it can be designed such that it acts as a point source with respect to the reflector. *PB 124554 Phase Centers of Electromagnetic Horns, Yueh-Ying Hu. Research Institute, Electrical Eng. Dept., Syracuse, N.Y. Library of Congress, Washington 25, D.C., Sept. 1954, 91 pp, Microfilm $5.40, Photostat $15.30.*

Test Apparatus For Memory Units

Design and construction data are described for a test apparatus for ferroelectric memory condensers which enables quick determination of optimum operating conditions and selection of condensers with identical properties for a particular application. The apparatus was designed for use in development of improved bistable storage condensers. The test reflects the practical applicability of the developed ferroelectric dielectric in a condenser structure through determination of switching characteristics, optimum switching pulse amplitude, and selection index. *PB 121204, Test Apparatus For Ferroelectric Memory Condensers, C. F. Pulvari, Catholic Univ. Amer. for Wright Air Development Center, Dec. 1955, 29 pp $.75.*

Linear-Phase Filters

This report presents *1.* a general image-parameter method for linear-phase electric filter design and *2.* a general insertion-loss method for design of electric filters possessing prescribed phase characteristics. Use is made of the electrostatic potential analogue in both methods. A simple method, using a Padé approximant, is introduced to obtain the insertion-loss characteristic from the image-parameter characteristic. *PB 124652 Linear-Phase Electric Filters, Byron J. Bennett, Stanford University, Electronics Research Lab., Stanford, Calif., Feb. 1952, 222 pp, Library of Congress, Washington 25, D.C., Microfilm $9.90.*

Control System Synthesis

This report presents a method for the direct synthesis of multipole control systems, i.e., control systems having a multiplicity of inputs and controlled outputs. Only linear systems are considered. An analysis is given of the factors which affect system stability together with a technique for stabilizing systems having plants with unstable elements. The concept of error coefficients is extended to multipole systems by the definition of an error coefficient tensor. Equations are developed which permit the explicit solution for the required controllers in terms of the given plant and the desired overall responses. *PB 123420 Synthesis of Multipole Control Systems, by Herbert Freeman, Dept. Electrical Eng., Electronics Research Labs., Library of Congress, Apr. 1956, 79 pp, Microfilm $4.50, Photostat $12.30.*

500 Ft Paraboloid Design

An inexpensive design for a fixed paraboloidal antenna of approximately 500 ft diam would consist of an array of telephone poles of appropriate lengths supporting flat panels of a size easily constructed from commercial timbers or structural steel beams and covered with hardware cloth. The panels might be approximately twenty feet in the longest dimension. For economy of material approximately square panels are desired. The mathematical analysis demonstrates that an antenna suitable for a minimum wavelength of sixteen centimeters would require approximately ninety panels of this size in each of twelve rings. *PB 121745 Design of a 500-Foot-Diameter Faceted Paraboloidal Antenna, W. R. Ferris, U.S. Naval Research Lab., OTS, Washington 25, D.C., Jan. 1957, 8 pp, $0.50.*

Angular Accuracy in Radar

The determination of the angular position of a target with search radar data is treated as a problem in estimating statistically the value of a parameter of a population. A computer was constructed in the form of a simulator which duplicates the entire search radar process in real time and produces an output whose characteristics are the same as those of an actual radar receiving echoes from a flying target. An estimator which can be implemented in a practical situation is applied to the simulator output. The distribution of this estimator is found for various values of the radar system parameters. *PB 123399 Analysis of Angular Accuracy in Search Radar, Robert Bernstein, Columbia Univ., Dept. Elec. Eng., Electronics Research Labs. Library of Congress, Washington 25, D.C., May 1955, 173 pp, Microfilm $8.10, photostat $27.30.*

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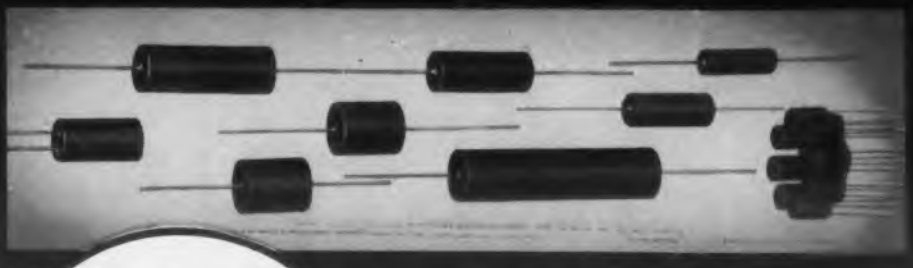

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Now your resistor, coil, capacitor, etc., can be encapsulated without the expense of temporary molds, release agents, and patching. The component is inserted into the new E-Case shell and epoxy compound added. A chemical reaction between the compound and epoxy shell assures a completely encased component resistant to humidity, temperature variations, and corrosive influences. The E-Case shells make mass production techniques possible in the encapsulation of components. Labor savings as high as 50% have been effected.

E-CASE SHELLS *completely eliminate:*

• mold problems • clean-up of mold and application of release agent • patching • removal of component from mold

Electrical Properties	Dielectric Strength Volts/Mil	380
	Surface Resistivity Ohm-cm	10^{14}
	Volume Resistivity Ohm-cm	10^{14}
	Dielectric Constant 60 CPS	6.7
	10^{6} CPS	5.4
	Power Factor 60 CPS	.027
	10^{6} CPS	.038
Physical Properties	Tensile Strength PSI	6,000
	Compressive Strength PSI	17,000
	Flexural Strength PSI	8,500
	Excellent Chemical and Solvent Resistance	

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CIRCLE 237 ON READER-SERVICE CARD FOR MORE INFORMATION

Report Briefs

Asymmetric Dipole Properties

This report describes an experimental investigation of asymmetrically-fed cylindrical antennas. Radiation pattern and input impedance data are presented for a wide range of antenna parameters. The measured data are compared with data computed from several analytical expressions found in the literature and the usefulness of these expressions is discussed. *PB 123978 Properties of the Asymmetric Dipole, Irene Carswell, Stanford Research Inst., Menlo Park, Calif. Library of Congress, Washington 25, D.C., Dec. 1955, 67 pp, Microfilm $3.90, photostat $10.80.*

Dynamic Systems Studies

Seven parts of a final report of research for the Air Force into tools and techniques for an air weapon system dynamics laboratory have been released to the public through Office of Technical Service. They are all entitled Dynamic System Studies and were published in September 1956. The volumes are: *PB 121596, Part 1:* Conclusions and recommendations. Advisory Board on Simulation, University of Chicago. 40 pp, $1.00. Conclusions, recommendations, and a history of the project are discussed briefly. *PB 121597, Part 2:* The Design of a Facility. B. E. Howard, University of Chicago, 35 pp, $1.00. The research program is divided into studies of mission, staff, operation and equipment. Each is summarized. *PB 121658, Part 4,* Technical Staff Requirements. W. R. Allen and M. C. Weiss, University of Chicago, 59 pp, $1.50. Requirements for technical personnel and laboratory organization are set forth. *PB 121598, Part 7,* Digital Computers, R. H. Farrell, University Chicago, 130 pp, $3.25. The role of computers in simulation and the present state of digital computation are reviewed. The OARAC is described, a check problem is coded for it, and equations are given for the check problem. *PB 121577 Part 13,* Error Studies, F. B. Wright, University Chicago, 78 pp, $2.00. Evaluation of complex computer equipment and results by means of the error theory is studied in detail. *PB 121706, Part 14,* Error Analysis for Differential analyzers, K. S. Miller, N.Y.U., and F. J. Murray, Columbia Univ., 97 pp, $2.50. A mathematical basis is derived for a general error analysis of the solution of systems of ordinary differential equations. *PB 121651, Part 16,* Aerodynamic Studies, M. Saarlas, University of Chicago, and M. Z. Krzywoblocki, University of Illinois, 54 pp, $1.50. What is now known about aerodynamics, why more is not known, and what is being done to supply more practical information on the phenomena are discussed in terms of fundamental principles and problems. *OTS, U.S. Dept. Commerce, Washington 25, D. C.*

Ferroresonant Subharmonics

The responses of a series RLC circuit with nonlinear inductance subjected to periodic voltages are analyzed to determine conditions for subharmonic response. The effect of hysteresis in the iron and of large nonlinearity is studied on the basis of idealized coil characteristics. Normalized parameters for hysteresis loop width and saturation flux linkages are introduced in connection with coercive force, capacitance, impressed frequency and impressed frequency and impressed voltage amplitude. The occurrence conditions for the various types and orders of subharmonic responses are then derived on the basis of the idealizations. Two types of subharmonic and fundamental frequency responses are predicted: symmetrical and unsymmetrical describing whether the response has half wave symmetry or not. *PB 124168 Subharmonic Responses of the Ferroresonant Circuit, E. Brenner, Polytechnic Inst. Microwave Research Inst., Bklyn, N. Y., Library of Congress, Washington 25, D.C., June 1955, 78 pp. Microfilm $4.50, photostat $12.30.*

Design of Accelerators

This report discusses linear electron accelerator design with particular emphasis on the choice of operating wavelength. Only one type of accelerator structure, the disk-loaded waveguide, is considered, but the principles discussed can be applied to other structure types as well. A set of criteria is described for the evaluation or comparison of different accelerator designs. Detailed analysis and design curves are given in separate appendices. Appendix A discusses the shunt impedance and related characteristics, B beam loading, and C the characteristic derivatives for determining dimensional tolerances. *PB 123972, Choice of wavelength and characteristic parameters in the design of linear electron accelerators, E. L. Chu and E. L. Ginzton. Stanford University. W. W. Hansen Laboratories of Physics, Microwave Laboratory, Stanford, Calif. LC. Washington 25, D. C. Mi $4.50, ph $12.30.*

Debye Potentials Applied to Fields

This paper discusses the question as to what class of electromagnetic fields can be represented by Debye potentials. The principal finding is that an arbitrary electromagnetic field, defined in region $a<r<b$ can be represented by a pair of Debye potentials associated with this coordinate system. *PB 123402 On the representation of electromagnetic fields by Debye potentials, Calvin H. Wilcox. U. S. Air Force. Air Research and Development Command. Cambridge Research Center. Electronics Research Directorate. Antenna Laboratory, Bedford, Mass. LC. Washington 25, D.C. July 1955, 17 pp. Microfilm $2.40, photostat $3.30.*

Report Briefs

Reflectors for Beam Shaping

Techniques based on geometrical optics are used to develop design formulae for doubly curved reflectors which will give radiation beams of a prescribed shape when employed with certain primary feeds. The quasi-point-source feed considered here is encountered in horns fed by rectangular waveguide and flared in either the E-plane or the H-plane but not in both simultaneously. Tests on a reflector designed using these formulae gave results which agreed well with those calculated. *PB 124258 Double-Curvature Reflectors for Beam Shaping with Quasi-Point-Source Feed, A. E. Marston. U.S. Naval Research Lab., OTS, Washington 25, D.C., May 1952, 12 pp. Microfilm $2.40, photostat $3.30.*

Tube Environment

It is proposed that reliable operation of receiving electron tubes in high effective environmental temperatures and pressures is possible only if the plate temperature is held to a defined safe value. A practical means is suggested for extrapolating the plate dissipation rating in order to hold temperature to the safe value; a validity test is set forth. Part II gives information on plate dissipation rating extrapolation curves for certain subminiature tube types; general curves showing constant plate temperature contours; evidence showing that internal tube temperatures are not directly affected by environmental conditions; an empirical method for determination of the maximum bulb temperature; and confidence limits on maximum bulb temperature and plate temperature showing variation by manufacturer. *PB 111575, Part I, PB 121780, Part II, A Study of Environmental Temperature and Pressure Effects On the Plate Dissipation Rating of Receiving Tubes, B. M. Schmidt, Univ. Dayton for Wright Air Development Center. Part I—Oct. 1953, 48 pp, $1.25, Part II, Dec. 1955, 40 pp, $1.00.*

Diode Amplification

This report has been written as an aid in the understanding of the process of amplification in diodes and of the physical properties that have a bearing on such amplifications; it shows the dependency of diode amplification on post-conduction phenomena. Typical waveforms show no apparent advantages over present components and add considerable difficulty in application. *PB 124644 Engineering Aspects of Diode Amplification, C. G. Dorn, U.S. Naval Ordnance Lab., Computer Components Div., Corona, Calif., Library of Congress, Washington 25, D.C., July 1956, Microfilm $2.40, photostat $3.30.*

Semiconductor Research

Contents: *1.* Photocurrent decay time in tellurium, by David Redfield; *2.* Sensitization of potassium chloride crystal to x-ray coloration, by Lang-Ying Lin; *3.* Effects of heating in air on the Hall coefficient of tellurium, by Donald Long; *4.* Pressure dependence of resistivity of Mg_2Sn, by Donald Long; *5.* Dependence of dielectric constant on density of aggregates, by Robert S. Smith. *6.* Change of length of ionic crystals due to x-ray irradiation, by Lang-Ying Lin; *7.* Chemisorption, photoconductivity and photodesorption in zinc oxide, by David B. Medved; *8.* Measurements of the complex dielectric constant and Faraday rotation in semiconductors at microwave frequencies, by Richard R. Rau. *PB 124172 Semiconductor-Research, Pennsylvania Univ., Dept. Physics, Philadelphia, Pa., Library of Congress, Washington 25, D.C., Jul. 1955, 270 pp, Microfilm $2.70, photostat $4.80.*

Teflon Capacitors

Capacitors of polytetrafluoroethylene material were found superior to those of mica. The Teflon met or exceeded all requirements for replacement of mica capacitors (specification MIL-C-5A) under temperatures from minus 60 to 200 C. The single exception was rf current rating, which could not be applied to metal-cased units because of overheating. At the conclusion of the research only two obstacles remained before Teflon capacitors could replace mica units in almost any application. The problems, neither serious, were stabilization of capacitor elements and encasement for radio-frequency operation. *PB 111729 Development of Subminiature High Temperature Capacitors, Balco Research Labs. Wright Air Development Center, OTS, U.S. Dept. Commerce, Washington DC, March 1955, 79 pp, $2.00.*

Design For Climatic Effects

For the design engineer concerned with circuit construction and packaging against environment this report may be of use. It is an analysis of worldwide climatic conditions by the Army; the results are published as a design guide to environmental extremes which might damage military equipment. Environmental stresses studied were thermal, humidity, precipitation, wind, penetration, and abrasion, salt spray, and atmospheric pressure. Probable and practical extremes were determined for each. Conditions were established for design and evaluation of military equipment for use under worldwide, hot-desert, arctic-winter, and moist-tropical climatic extremes. *PB 121741 Climatic Extremes for Military Equipment, N. Sissenwine and A Court, Office of Quartermaster General, Dept. of Army, Nov. 1951, 70 pp, $1.75.*

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Patents

Controlled Single-Sideband Transmitter

Patent No. 2,774,041. James L. Finch. (Assigned to Radio Corp. of America)

The transmitter consists of a single sideband generator to which a band of modulation frequencies is supplied. A single sideband amplifier amplifies the single sideband. The input of the amplifier and the output of the generator are coupled together which coupling includes a controllable-gain amplifier. A predetermined range of modulation frequencies in the single sideband output of the generator controls the gain of the controllable-gain amplifier.

Capacity Sensitive Relay

Patent No. 2,774,919. Ralph V. Coles. (Assigned to Robertshaw-Fulton Controls Co.)

The circuit of the invention relates to an impedance sensitive device energized by a source of alternating voltage. The circuit uses an oscillator consisting of a tube and an oscillatory tank circuit between the grid of the tube and one side of the source. The electrical center of the tank circuit is connected with the cathode. The other side of the source is connected with the anode of the tube. A variable impedance is used with the oscillatory tank circuit in any suitable way for varying the amplitude of oscillation.

Beam Cut-Off Circuit

Patent No. 2,774,007. John F. Bigelow. (Assigned to International Telephone and Telegraph Corp.)

A protective circuit for a cathode ray tube is provided which is operative to cut off the beam source when sweep or deflection pulses cease. The circuit uses an electron discharge tube which operates between a state of conduction and a state of non-conduction and functions to control the beam in response to the presence or absence of deflection pulses. The particular circuit means for initiating and terminating conduction through this discharge tube in response to deflection pulses is a two element gas tube serving as a diode rectifier. The gas tube is connected in series between the grid and cathode of the control tube. Also a resistance shunts the gas tube. Normally the electrodes of the gas tube are biased below striking voltage and also at a level such that deflection pulses of a predetermined minimum value and a given polarity render the gas tube conducting while deflection pulses of like value and opposite polarity lower the normal bias of the gas tube below striking voltage. Conduction through the tube is thereby prevented. The deflection pulse source is connected to that electrode of the gas tube which is connected to the grid of the control tube.

Phase Discriminator

Patent No. 2,774,038. Gus Stavis. (Assigned to International Telephone and Telegraph Corp.)

It is frequently necessary to measure the phase difference between two signal voltages. The patentee has devised a network for accomplishing this measurement using two loop circuits each having a directional element and a load resistor. Two relatively high level voltages which have magnitudes proportional to and greater than the signal voltages is applied to the network and produces in one of the loop circuits a resultant voltage which is equal to the difference between the high level signals plus one of said signal voltages. In the second loop circuit, a resultant voltage is also produced between the high level voltages minus the other of the signal voltages. The d-c voltage measured across the load resistors is then proportional to the difference in phase between the signal voltages.

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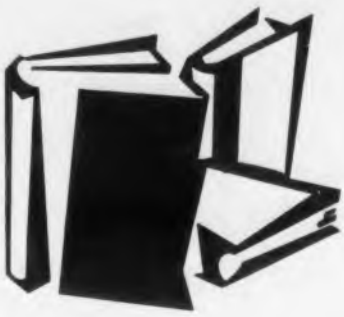

Books

The Prospects of Nuclear Power & Technology

Gerald Wendt, D. Van Nostrand Co., Inc., 120 Alexander St., Princeton, N.J. 347 pages, $6.00.

A thoughtful appraisal—international in scope—of the future of industry and society in a nuclear age is presented by Dr. Wendt. The book is divided into two parts. Part 1 gives an overall picture of actual and projected atomic plants in the United States and abroad and describes the new problems that they introduce in such realms as finance, insurance and governmental controls. Dr. Wendt gives serious attention to the immense economic and social upheaval of this new age, offering no pat solutions, but suggesting to every reader how his own life and work may be altered. Typical effects discussed are a relocation of industry in every country, a redistribution of populations, and the freeing of men's working and living habits from old considerations of power availability. In addition to these changes which atomic energy will bring about, he discussed the establishment of regional atomic authorities by groups of nations and the International Atomic Energy Agency of the United Nations to strengthen the present experiments in economic cooperation.

Part II, entitled "Technology" covers in detail the mineral resources available, the nuclear fuels needed, the new metals and materials used in the construction of nu-

clear reactors and the design of various types of reactors. Problems as yet unsolved of processing, extraction and disposal of fission products are also discussed. The author indicates the great potential of the nuclear industries in the generation of electric power, the production of heat for the chemical and process industries, in transportation by sea, rail and air, and in the manufacture of isotopes and other new materials with resulting advances that will affect the life and well-being of every citizen.

Electricity and Magnetism

J. Newton, Philosophical Library, 15 East 40 St., New York 16, N.Y. 613 pages, $10.00.

Starting with the introductory considerations of static-electricity and permanent magnetism, Mr. Newton builds up a consistent theory of electricity and magnetism. The order of treatment leads to a more balanced and interesting approach to the subject without making any sacrifice in the logical development. It avoids placing undue emphasis on electrostatics and magnetism, the detailed considerations of these being deferred until later. The many fundamental, but often abstract, concepts which are met within a study of electricity are fully explained. Information of a more technical character has been included where appropriate, to assist the reader to appreciate the practical aspects of electrical science. The metric-kilogram-second system is used throughout the text.

Proceedings of the Second RETMA Conference on Reliable Electrical Connections

Engineering Publishers, G.P.O. Box 1151, New York 1, N.Y., 103 pages, 53 illustrations, $5.00.

Techniques, tools, materials and measurements are examined in this collection of practical information about electrical connections. The book contains papers by 13 authorities and supplementary data contributed by 23 others. Some of the subjects discussed are soldered connections, solderless connections, brazed connections, ultrasonic joining, equipment and tools, fluxes, surface qualities, soldering to printed wiring boards, contamination, solderable wire coatings, operator influence, and reliability evaluation.

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What the Russians are Writing

J. George Adashko

Contents of Radiotekhnika i Elektronika No. 9, 1956

Circuit Theory

Use of Underexcited RC Oscillators as Band Filters, L. N. Kaptsov (5 pp, 4 figs).

A system consisting of two underexcited RC oscillators is equivalent to a system of two interconnected LC networks and can therefore be used as a low-frequency band filter. The actual and equivalent circuits of such a filter are shown in the figures. The article is devoted to the calculation of the self and transfer impedances of the circuit.

Guided Waves

Propagation of Electromagnetic Waves in Slightly Bent Waveguides, A. G. Sveshnikov, (8 pp).

Classical (Maxwell-Equation) analysis of propagation in an infinite waveguide of round-cross section bent locally around a circular arc or a sine wave. Suitable approximations are assumed to make the calculations manageable. A related article by B. Z. Katsenelenbaum appeared in Radiotekhnika i Elektronika No. 2, February 1956, and was reported in the Nov. 15, 1956 issue of Electronic Design.

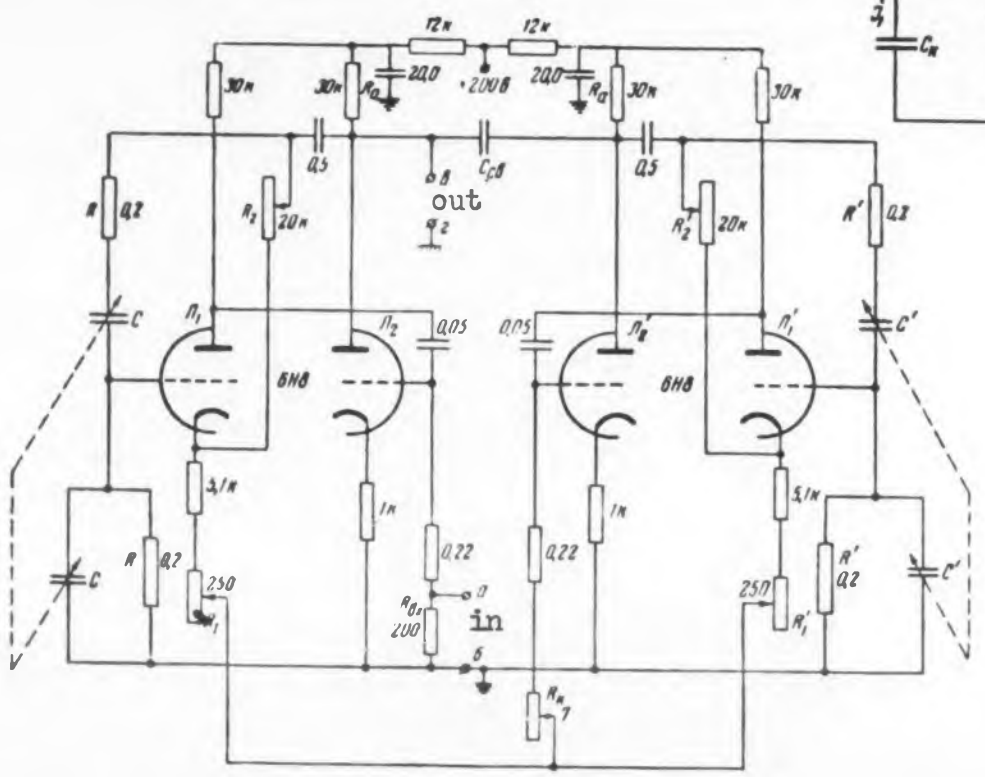


Fig. 1. Diagram of low-frequency band filter consisting of two identical underexcited oscillators.

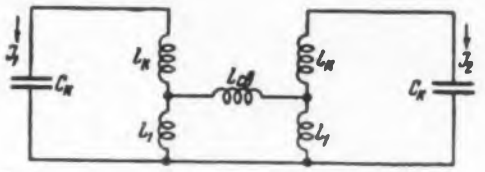


Fig. 2. Equivalent diagram of a system of two coupled RC oscillators.

Gyrotropic Cylindrical Waveguide of Infinite Length (Survey of Theory), R. G. Mirimanov, L. G. Lomize, (27 pp, 6 figs, 2 tables).

Presents modern theories of propagation of various modes in cylindrical gyrotropic waveguides. All derivations and calculations are made for a waveguide solidly filled with ferrite. The computations made for H-modes are compared with experimental data and are used to show that the Faraday effect is most pronounced for H_{11} modes. In all other modes, the rotation of the polarization plane is much less. Theoretical equations are also derived for a gyrotropic cylindrical waveguide with transverse magnetization. Numerous American papers are cited.

Microwave Components

Frequency Multiplication in Reflex Klystron, E. N. Bazarov, M. E. Zhabotinski, (1 pp, 1 fig).

To effect the frequency multiplication it is necessary to suppress the klystron self-oscillations, and the resonator must be tuned to the desired harmonic and excited at the fundamental frequency. The theoretical aspects of frequency multiplications are essentially the same as those of frequency division, to which an article by the same authors was devoted in the May 1956 issue of Radiotekhnika i Electronika. This brief article reports on the means used to improve the conversion effectiveness.

Influence of Trajectory Angle of Electrons in a Tube on the Synchronizing Action of an External Signal, F. M. Klement'ev, (4 pp, 3 figs).

Analysis of the stationary processes in a reflex klystron oscillator excited by an external sinusoidal voltage. It is shown that if the trajectory angles in

the reflex klystron are not at their optimum values, the amplitude curve becomes deformed. Conditions are derived for stable synchronization.

Measurements and Instruments

On the Measurement of Dielectric Constant of Materials with High Conductivity (Semiconductors), F. M. Popov (4 pp, 1 table).

The dielectric constant of several semiconductors (CuO, ZnS, CdS, ZnTe, HgS, and others) was determined experimentally by measuring the dielectric constant of a two-component mixture consisting of the unknown semiconductor and a substance of known dielectric constant (mostly paraffin). This gets around the difficulty of measuring the dielectric constant of a pure semiconductor of relatively high conductivity. The author does point out, however, the approximate nature of the equations used to determine the final results.

Electron Multipliers for Recording Corpuscular and Hard Electromagnetic Radiations, T. M. Lifshits, (12 pp, 14 figs, 2 tables).

Description of electron multipliers with emitters made of activated copper-aluminum-magnesium alloy, used to record corpuscular radiations. The gain of such multipliers is on the order of 10^9-10^{11}, and the background count is 3-5 pulses per minute when operated at 4000 volts. The use of only metals in the photo-cathodes makes it possible to use these multipliers with ultraviolet light or with X rays. Reference is made to many American articles on the subject.

Communication and Information Theory

Increasing the Transmission Effectiveness of Television Signals, D. A. Novik, (10 pp, 3 figs).

Discussion of the compression of television signals using a system that allows for the statistical features of the signal, with the time scale of the television signal subjected to two reversible redistributions (transformations). An analysis is made of the reversibility of the redistribution operation in an electric signal, the possible bandwidth gain, and the effect of noise in the system. The features of "memory" tubes operating under variable scanning speeds are discussed, and the linear distortion in systems with variable scanning speeds is touched upon. Possible applications are proposed.

Minimum Noise Factor of a Double-Beam Tube, S. K. Lesota, (4 pp, 1 fig).

The noise factor is calculated for arbitrary correlations between the longitudinal fluctuations of the current and voltage in the two-beam stream.

Fluctuations in a Vacuum Tube Oscillator in the Presence of Grid Current, L. I. Gudzenko, (15 pp, 3 figs).

In spite of the large amount of material published on fluctuations in vacuum tube oscillators, little has been published on the effect of grid current. The author employs statistical methods to calculate the fluctuations produced by the thermal noise and by shot effect for tuned-plate, tuned-grid, and self-bias operation. The suppression of shot effect by space charge is neglected.

Selection of Optimum Time Constants in Complicated Pulse Systems, S. N. Krize, (3 pp, 1 fig).

To design an overall pulse system for a prescribed time constant it is necessary to select a time constant for each network in the system and obtain an optimum combination of time constants. As usual, the designer must carefully balance gain (which calls for a large time constant) vs. fidelity (which calls for a small time constant). The author shows that minimizing the ratio of gain to time constant gives the desired values of individual time constants.

On the Fluctuating Character of the Amplitude Buildup Time of Self-Excited Oscillators, V. I. Tikhonov (6 pp, 1 fig).

If the parameters of an oscillator are such that it is capable of self oscillation, the electrical fluctuations inherent in the system, such as thermal fluctuations in resistors or fluctuations in tube current, will eventually start the oscillator going without "large" external electric stimuli. This phenomenon is of some importance in certain pulse-modulated circuits, and is treated analytically in this article, using linear approximation.

Amplifier Design With Simple HF Compensation

J. George Adashko

CONSIDER the amplifier stage given in Fig. 1. The equations usually given for the design of this stage are valid for an infinitely large internal tube resistance R_i and leakage resistance R_g. This assumption may lead to substantial errors when the load resistance R_a is not very small compared with the internal and leakage resistance in parallel. Derived below are equations which make it possible to calculate and design this stage without making the previously mentioned assumptions concerning R_i and R_g.

Starting with the equivalent circuit shown in Fig. 2, it is easy to obtain an expression for the relative amplification coefficient

$$y = \frac{1+ixk}{1-x^2\,k+ix\,(1+k-ak)}$$

and for its modulus

$$y = f(x,k,a) = \frac{(1+x^2\,k^2)^{\frac{1}{2}}}{(1+x^2\,[(1+k-ak)^2-2k]+x^4\,k^2)^{\frac{1}{2}}} \quad (1)$$

Here $x = C_0R_0$, the relative frequency;

$C_0 = C_{0\,min} + \Delta C$;

$C_{0\,min}$ is the capacitance in parallel with the tube;
ΔC is the capacitance of additional capacitor connected (if necessary) across the tube;
the compensation coefficient;

$$R_0 = \left(\frac{1}{R_a} + \frac{1}{R_i} + \frac{1}{R_g}\right)^{-1}$$

$$k = \frac{L}{C_0\,R_0\,R_a},$$

$a = R_0/R_a$, a parameter less than unity.
The function $y = f(x,k,a)$ can reach a maximum y_m at a certain value x_m.

From the equation $d/dx\ f(x,k,a) = O$ we readily obtain

$$x_m = \frac{([(k+1)^2 - (1+k-ak)^2]^{\frac{1}{2}} - 1)^{\frac{1}{2}}}{k} \quad (2)$$

Substituting this value of x into the expression $f(x,k,a)$ we obtain after several transformations

$$y_m = \frac{1}{(1 - x_m{}^4\,k^2)^{\frac{1}{2}}} \quad (3)$$

Setting x_m in eq(2) equal to zero, we solve the resultant equation for k:

$$k = k_0 = \frac{1}{a + \sqrt{2a}} \quad (4)$$

k_0 is the critical value below which x_m becomes imaginary. At $k = k_0$ we obtain:

$$y = \frac{(1 + k_0^2\,x^2)^{\frac{1}{2}}}{(1 + k_0^2\,x^2 + k_0^2\,x^4)^{\frac{1}{2}}} \quad (5)$$

This equation makes it possible to determine the upper frequency limit x_u for a specified gain y_u at this frequency:

$$x_u = \left[\frac{1 - y_u^2}{2\,y_u^2}\left(1 + \left[1 + \frac{4\,y_u^2}{1 - y_u^2} \cdot \frac{1}{k_0^2}\right]^{\frac{1}{2}}\right)\right]^{\frac{1}{2}} \quad (6)$$

Table 1 gives the values of k_0, calculated from eq(4) for several values of the parameter $a = R_0R_a = R_{ig}/R_a + R_{ig}$ and the ratio $R_{ig}/R_a = a/(1-a)$.

After solving equations (2) and (3) with respect to k and x_m we obtain the equations

$$k = \frac{1}{a - m + \sqrt{2a\,(1-m)}} \quad (7)$$

and

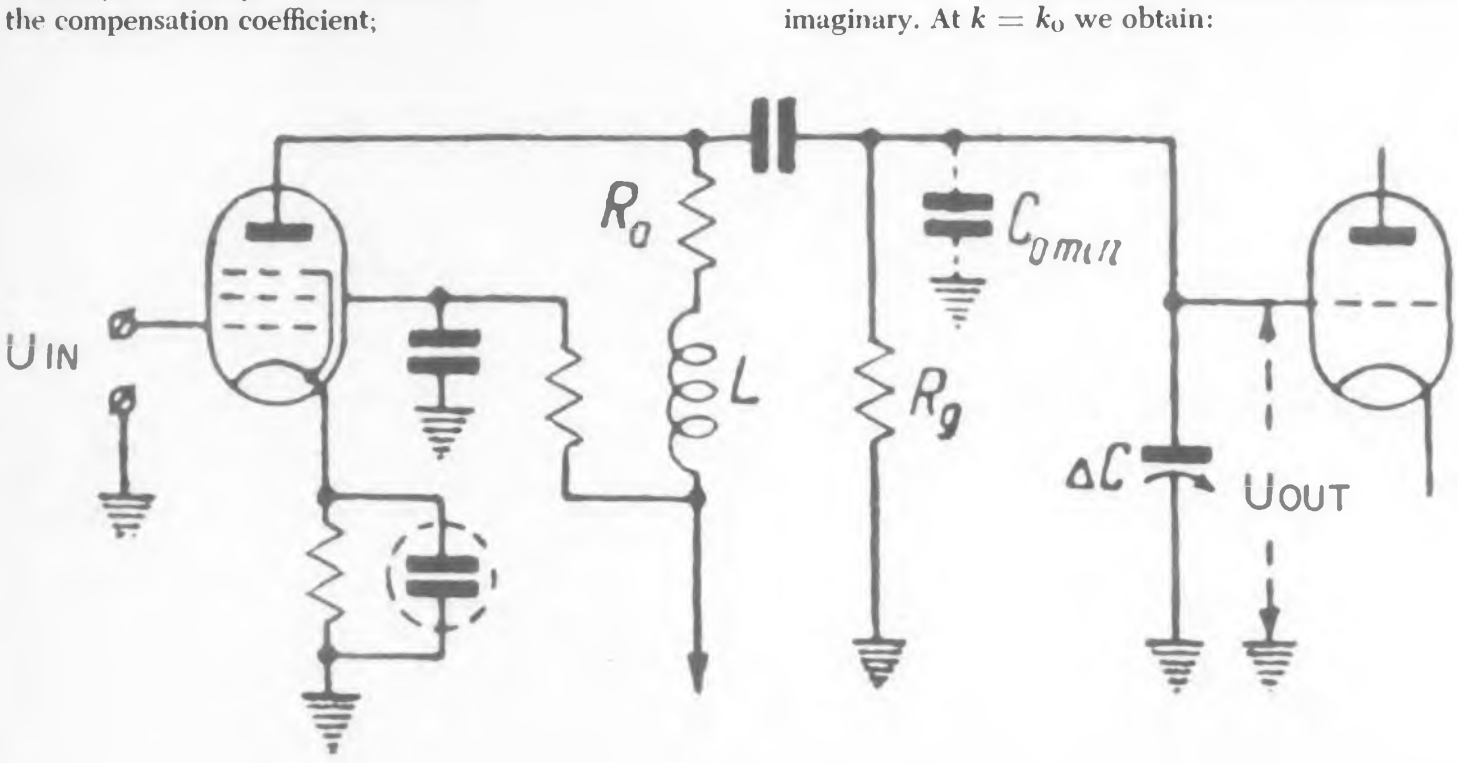
$$x_m = \left(\frac{m}{k}\right)^{\frac{1}{2}} \quad (8)$$

where

$$m = \frac{\sqrt{y_m^2 - 1}}{y_m} \quad (9a)$$

and

$$1 - m = \frac{1}{y_m\,(y_m + \sqrt{y_m^2 - 1})} \quad (9b)$$



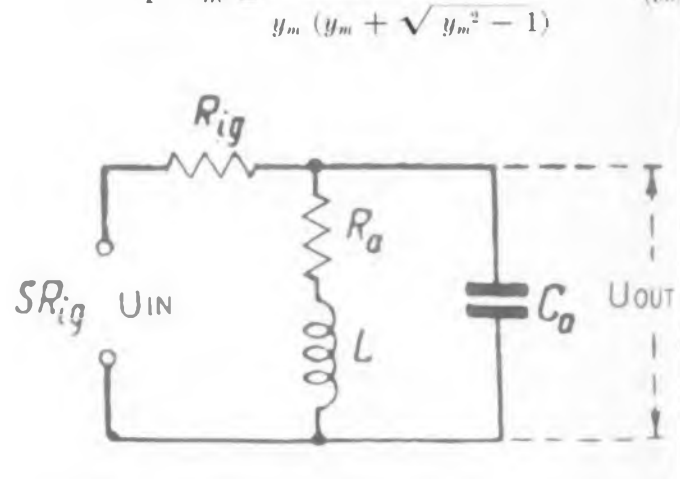


Fig. 1: (left) Typical pentode amplifier stage. It is possible to design this stage without assuming that the internal tube resistance and the leakage resistance (R_g) are infinite.

Fig. 2: (above) Equivalent circuit of amplifier shown in Fig. 1.

ince $k \geq 0$, the following condition should hold:

$$m < \sqrt{2a - a^2} \tag{10a}$$

or

$$y_m < \frac{1}{1-a} \tag{10b}$$

If this condition is not satisfied, the selected value of y_m can not be realized.

To facilitate the calculations it is advantageous to use eqs (2) and (3) to prepare plots such as shown in Fig. 3 of x_m and y_m vs. k at various values of the parameter a.

Here are several examples on how the above equations can be used in design.

Assume that to compensate for the frequency characteristic of the amplifier as a whole it is necessary to raise the frequency characteristic of a given stage, employing a pentode tube. Let the gain at the frequency $f_m = 8{,}000$ cps have to be raised at 3 db. Assume that R_i, R_g, R_a and R_{0min} are given, say $R_i = R_g = 1$ meg, $R_a = 0.1$ meg, and $C_{0\,min} = 50$ μμf. The problem is to determine L and ΔC.

The solution is carried out in the following sequence.

We determine $a = R_0/R_a = 0.08/0.1 = 0.8$, and knowing $y_m = 1.41$ (corresponding to 3 db) we obtain from eqs (7) and (8) the correction coefficient k ($k = 1.28$)and the relative frequency x_m ($x_m = 0.74$).

We now obtain from expression $x_m = 2\pi f_m C_0 R_0$

$$C_0 = \frac{x_m}{2\pi f_m R_0} = \frac{0.74 \times 10^{12}}{2\pi \times 8000 \cdot 8 \cdot 10^4} = 184\ \mu\mu f$$

and $\Delta C = C_0 - C_{0\,min} = 184 - 50 = 134$ μμf.

We determine the inductance L from the expression $k = L\,C_0 R_0 R_a$.

The inductance L should have a minimum distributed capacitance C_L. It is necessary to check whether this capacitance can distort substantially the result obtained. To be able to neglect this quantity, it is necessary that the following condition be satisfied

$$\omega_u L < \frac{0.1 \text{ to } 0.2}{\omega_u C_L} \tag{11}$$

where ω_u is the upper-boundary circular frequency.

As a second example again let $R_i = R_g = 1$ meg and $R_a = 0.1$ meg. Let $C_0 = C_{0\,min} = 50$ μμf and $y_u \sqrt{2} = 0.707$, corresponding to a decrease in gain of 3 db.

It is necessary to determine the upper boundary frequency f_u and the inductance L for the case of the flattest frequency characteristic. To determine this quantity we first calculate the parameter $a = R_0/R_a$. As in the preceding case, we find $a = 0.8$. Using equation (4) of Table 1 we obtain the corresponding value $k_0 = 0.484$. From equation (6) we get $x_u \approx 1.62$. The unknown frequency is found from $x_u = 2\pi f_u C_0 R_0$ to be 64.5 kc.

The inductance L is given by $k = L/C_0 R_0 R_a$

$$L = 0.484 \times 50 \times 10^{-12} \times 8 \times 10^4 \times 10^5 = 0.194 \text{ henry}$$

The calculation and examples cited here show that a considerable rise in the frequency characteristic can be effected only in that case, when the parameter a is close to unity. The best way to obtain a value of a close to unity is byusing a pentode. It is easy to check that even a slight decrease in the parameter a, particularly in those cases when it is necessary to obtain a considerable rise in the frequency characteristic, leads to a considerable reduction in the gain. Therefore if a pentode is used it is also necessary to take the extent to which a differs from unity into account.

Where we to put into the first example $a = 1$ instead of $a = 0.8$, we would have an inductance that is 35 per cent smaller. Here the frequency characteristic would rise not by 3 db but by 1.7 db.

Appendix

Derivations of Equations (2) and (3).

Introduce the symbols $\eta = y^2$ and $\xi = x^2$. Then (1) becomes

$$\eta = \frac{A}{B} \tag{12}$$

where

$$A = 1 + \xi k^2$$

and

$$B = 1 + \xi\,[(1+k-ak)^2 - 2k] + \xi^2 k^2$$

Let us calculate

$$\eta' = \frac{d\eta}{d\xi}$$

and set the result equal to zero

$$A'B - AB' = 0 \tag{13}$$

Hence $A/B = A'B'$ at $\xi = \xi_m$, i.e., at the extremum point. Consequently

$$\eta_m = \frac{A'}{B'} = \left|_{\xi=\xi_m}\right. = \frac{k^2}{[(1+k-ak)^2-2k]+2\,\xi_m k^2} \tag{14}$$

We determine ξ_m from the equation (13), substituting in it the value of A and B and their derivatives.

After grouping similar terms we obtain

$$\xi_m^2 k^4 + 2\,\xi_m k^2 + (1+k-ak)^2 - 2k - k^2 = 0 \tag{15}$$

Solving this equation with respect to ξ_m and selecting the positive root, we obtain equation (2). To obtain equation (3) let us note that the denominator in the left half of equation (14) is $k^2 - \xi_m k^4$, which directly follows from expression (15). Substituting this into (14) we obtain the required results. (*Abstracted from an article by G. S. Ramm,* Electrosviaz' *No. 5, 1956, p. 32.*)

Abstract—German

Classification of Crystal

MANY OF the conventional crystal controlled oscillators can be shown to be special cases of two basic types of circuit arrangements. Because the conditions for oscillations can be fulfilled through either a basically series resonant or through a parallel resonant effect, the two types are termed "series resonant" (SR) or "parallel resonant" (PR) oscillators.

A crystal can be represented by the equivalent circuit shown in Fig. 1 (in the neighborhood of the natural frequency of the crystal). A basic oscillator circuit is shown in Fig. 2, where the crystal has been incorporated in a feedback arrangement, together with an amplifier (A) and two passive impedances Z_1 and Z_2. The representation of Fig. 2 requires that the input and output impedances of the amplifier are included in complex values Z_1 and Z_2 respectively (i.e. in parallel with the external impedances).

The conditions for oscillations are then fulfilled if the relationship

$$S = -\frac{Z + Z_1 + Z_2}{Z_1 Z_2} \qquad (1)$$

is fulfilled. In eq. (1), the impedances Z_1 and Z_2 are defined above, Z represents the impedance of the crystal and S is the complex transfer admittance of the amplifier (output current/input voltage).

To use eq. 1 we note first that the phase shift condition prescribed by the equations must be fulfilled, then if several absolute values of S satisfy the magnitude (gain) conditions, the oscillator will oscillate at that frequency which requires the least gain. We note also that the impedances Z_1 and Z_2 can be interchanged. If however the crystal is used in place of Z_1 (or Z_2) a new basic circuit, shown in Fig. 3 results, but eq. (1) can still be applied if the subscripts are exchanged appropriately. In every case, reactances can be connected in series or in parallel with the crystal and included in the term "Z".

The impedance of the crystal can be expressed as $Z = R + jX$ where in the calculation of the reactance X the capacitance C_o can often be neglected. In the neighborhood of resonance, the ap-

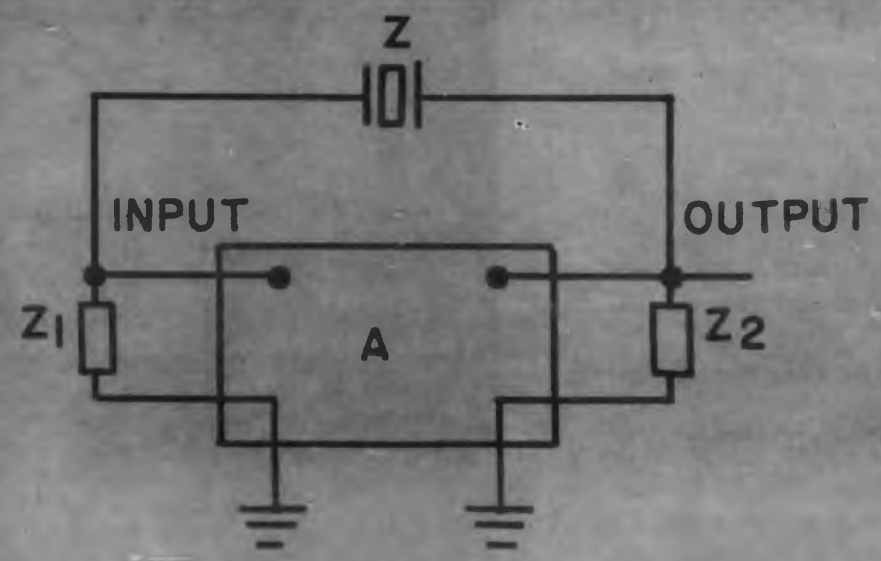


Fig. 2: Basic series resonant oscillator circuit.

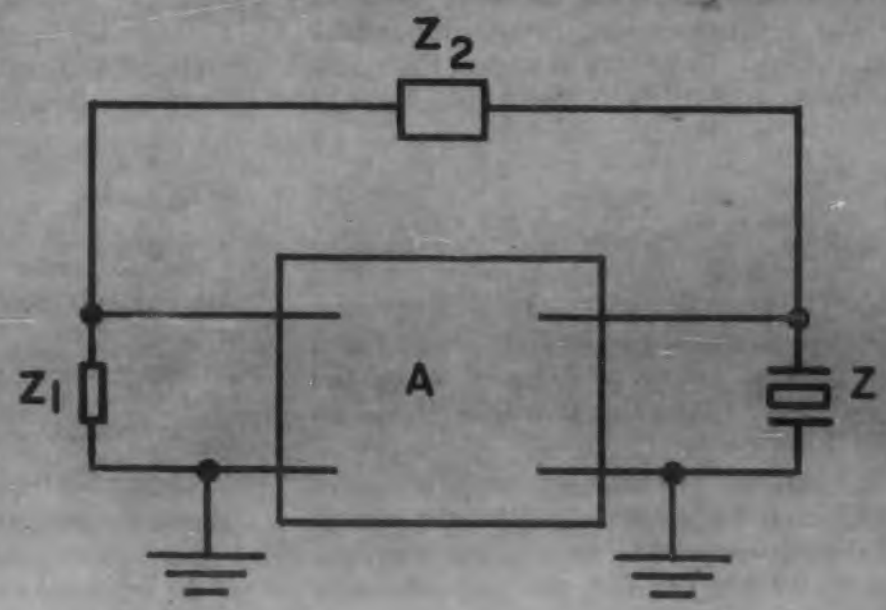


Fig. 3: Basic parallel resonant oscillator circuit.

Oscillators

E. Brenner

proximate form

$$f = f_o + X/4\pi L$$

can often be used, where f_o is the resonant frequency of the crystal.

The series resonant cases are summarized by the arrangement of Fig. 2. Using single elements for Z_1 and Z_2, one finds in every case that the condition for oscillations requires that the series reactance of Z, Z_1, and Z_2 be zero. The required sign of S and other pertinent data for the circuits represented by Fig. 2 are shown in Table I.

For the circuits represented by Fig. 3 it is found that the conditions for oscillations require that the sum of the crystal susceptance and the susceptances of Z_1 and Z_2 be zero, hence this scheme embodies the parallel resonant effects. Results for various combinations of Z_1 and Z_2 are summarized in Table II.

It should be noted that positive values of S can be obtained with one tube circuits (or two tubes with phase inversion) while negative S results from an even number of tubes without phase inversion. *(Abstracted from an article by Gerhard Becker,* Archiv der Elektrischen Uebertragunc, *Vol. 11, No. 1, Jan. 1957, pp 41-47.)*

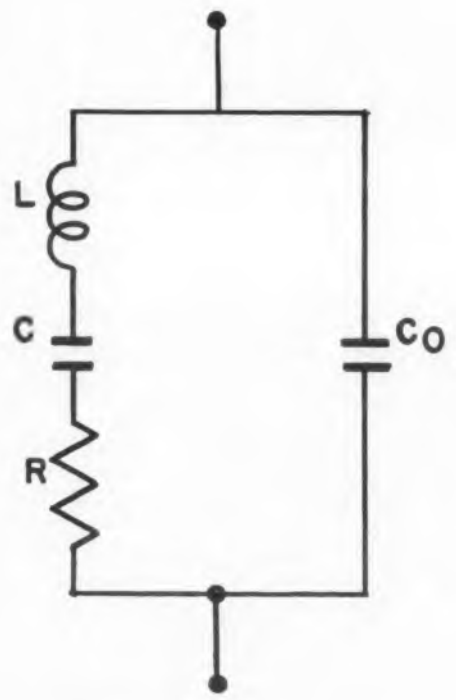


Fig. 1: Equivalent circuit of crystal (in the neighborhood of the natural frequency).

TABLE I SR OSCILLATORS (Fig. 2)

Case No.	Nature of Z_1	Nature of Z_2	Sign of	Frequency of Oscillator
1	R	R	negative	f_o
2	C	C	positive	more than f_o
3	L	L	positive	less than f_o
4	L	C	negative	★
5	C	L	negative	★

*The frequency may be equal to, larger or less than f_o.

TABLE II PR OSCILLATORS (Fig. 3)

Nature of Z_1	Nature of Z_2	Sign of X_1+X_2	Sign of S	compared Frequency to f.
C	C	negative	negative	larger
L	L	positive	negative	smaller
C	L	positive	positive	smaller
C	L	negative	negative	larger
L	C	positive	negative	smaller
L	C	negative	positive	larger
C	O	negative	negative	larger
L	O	positive	negative	smaller

Abstract—German

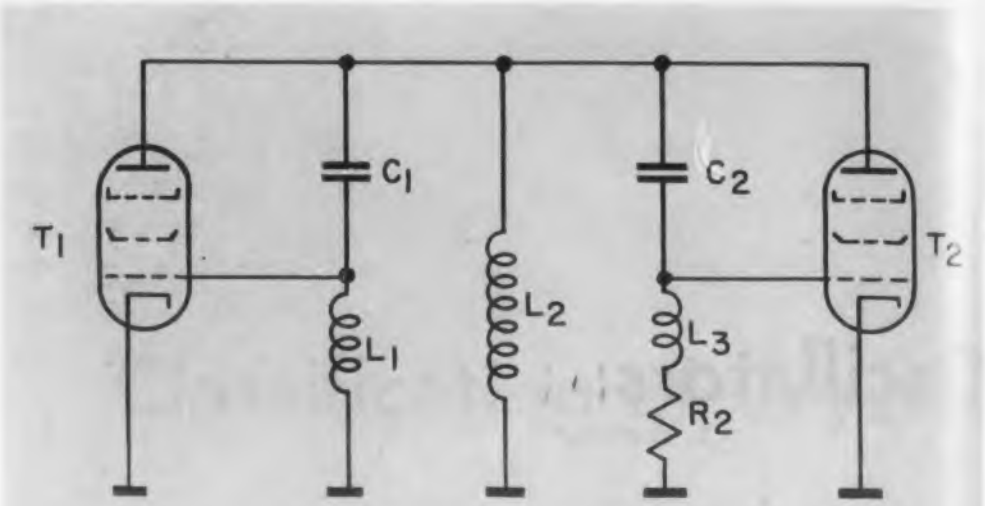


Fig. 1. Conventional wobbulator circuit. T_1 is an oscillator and T_2 is a reactance tube.

Wobbulator with Large Frequency D

FOR the visual examination of amplitude characteristics of two terminal pairs, wobbulators with relatively large frequency swing are necessary. The conventional wobbulator consists of a reactance tube stage which controls on oscillating stage and results in a frequency swing of about 5 per cent. In order to get the necessary frequency deviations mixing is then employed so that the entire wobbulator consists of three or four tubes. A simple one tube circuit which accomplishes the same purpose in the low and intermediate frequency range is discussed in this paper.

The development of this circuit can be understood if the circuit of Fig. 1 is first considered. The circuit of tube T_1 forms an oscillator. The tube T_2 is a reactance tube which would be purely reactive if L_3 were zero. The addition of L_3 results in a phase shift of more than 90 degrees. If L_3 is made sufficiently large then the oscillating stage can be omitted and the circuit of Fig. 2 results. This circuit is a simplified wobbulator which can give frequency deviations up to 50 per cent of the center frequency.

For the design of the circuit it is convenient to let $R_1 = R_2 = R$ and $L_1 = L_2 = L$. These conditions impose no hardship in the practical choice of components. One can then show that the conditions for oscillations are fulfilled in the frequency range ω_a to ω_b where these two frequencies are related to the mutual conductance of the tube (g_m) and the linear circuit parameters through the equations

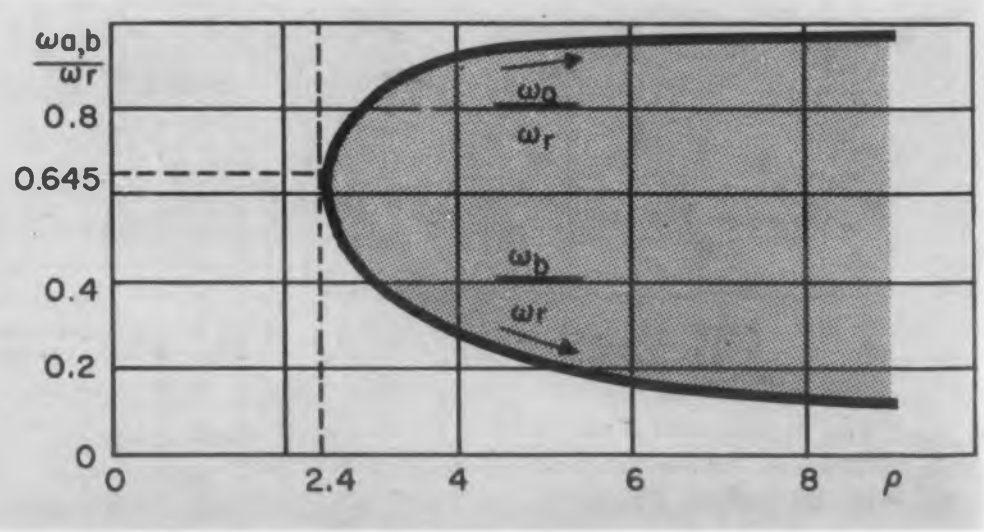


Fig. 3. Graph of eq. 1, showing the relationship between the extreme radian frequencies ω_a and ω_b (normalized) and the circuit parameters.

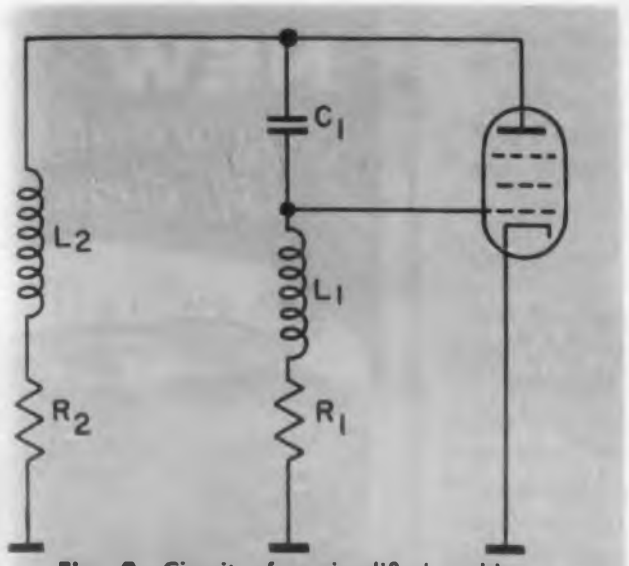


Fig. 2. Circuit of a simplified wobbulator capable of frequency deviations up to 50 percent of the center frequency.

y Deviation

E. Brenner

$$\frac{\omega_{a,b}}{\omega_r} = \left[\frac{1}{2} - \frac{1}{2\rho^2} \pm \sqrt{\frac{1}{4} - \frac{3}{2\rho^2} + \frac{1}{4\rho^4}}\right]^{\frac{1}{2}} \qquad (1)$$

$$(g_m)_{a,b} = \frac{4\rho/Z}{\rho^2\left(\frac{\omega_{a,b}}{\omega_r}\right)^2 - 1} \qquad (2)$$

where

$(g_m)_{a,b}$ are the values at which oscillations occur at the radian frequency ω_a and ω_b respectively

$Z = \sqrt{2L/C}$

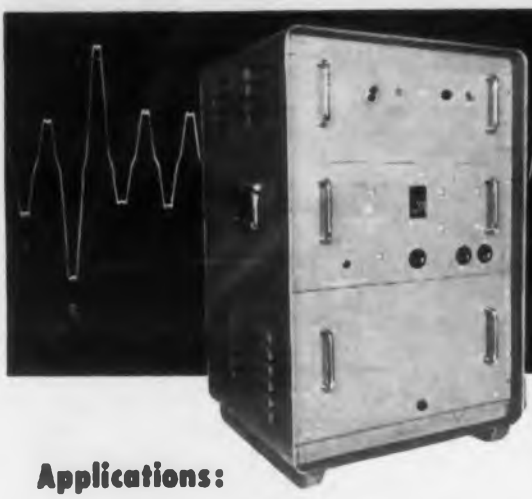
$\rho = Z/2R$

$\omega_r = 1/\sqrt{2LC}$

The complicated relationship given by Eq. 1 is shown in Fig. 3. It is concluded that ρ must exceed 2.4 to have frequency swing.

In order to have the output amplitude independent of the instantaneous frequency limiting diodes can be connected (bilaterally) between the grid and cathode of the tube.

Detailed experimental results are cited in the paper. At audio frequencies frequency variation exceeding the ratio of two-to-one were achieved while in the intermediate frequency range (up to about 1 mc) deviations slightly below the ratio of 2/1 are possible. *Abstracted from an article by E. G. Wonschi*, Nachrictentechnik, *Vol. 7, No. 2, Feb. 1957, pp 51-55.*



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Standards and Specs

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Color Code Standards

"A color code is worthless if it cannot be read." So states RETMA Standard GEN-101A, ASA STANDARD C83.1—1956, a comprehensive standard describing the colors recommended for indicating numerical values, decimal multipliers, tolerances and functions. Included in the standard are colored plastic chips corresponding to those recommended colors to permit visual comparison with the item being inspected.

These colors are intended for use in the marking of components such as resistors, capacitors, and wires in a manner described in the industry standards for these items. In addition, the use of these colors is recommended for the identification of terminals and circuit functions, and any other application where the relation of colors to numbers or functions would be advantageous.

The new standard is divided into five sections: section one contains the standard color code, section two describes the nominal color samples, section three defines the visual and colorimetric limits with hints on how to compare colors, section four gives helpful information on maintaining maximum readability and color performance, and section five provides additional data on non-standard colors.

The 10 standard colors are related to their numerical figures, decimal multipliers and value tolerances. Standard three-letter and alternate one-letter, abbreviations for these colors are given.

Nominal color samples are described in terms of the Ostwald Color Notation as presented in the Color Harmony Manual Third Edition. Each color chip is actually identified by the Ostwald color notations.

The standard not only defines each color, but also defines the pale and dark limits of each color. Recommendations are included for lighting the samples to insure accurate comparison.

In recognition of the current practice of utilizing colors other than standard, complete information on 10 secondary colors is given. Typical secondary colors are tan, pink, maroon, lime and jade.

Copies of the Supplemental Color Chips are available at $8.00 for a set of the 10 nominal colors and $20.00 for a complete set of the 28 nominal and limit colors. All sample chips are precisely-colored plastic hexagons approximately 1 sq. in. Chips are colored glossy on one side and flat on the other. Color chips may be obtained from RETMA Engineering Office, 11 West 42nd Street, New York 36, N. Y.

Copies of American Standard Color Coding for

Numerical Values, C83.1—1956, are available from American Standards Association, 70 East 45th Street, New York, N. Y., for $.50 each.

Abstracted from an article by J. A. Caffiaux, Do You Really See Red?, The Magazine of Standards, March, 1957.

Capacitors

MIL-C-003965A(USAF), Capacitors, Fixed, Electrolytic (tantalum), 4 December 1956

Tantalum, electrolytic, fixed capacitors, polarized and nonpolarized are covered by this spec. It is a graded spec having characteristics and grades covering ranges in temperature and vibration respectively. A typical type designation for a capacitor meeting this spec follows: ECL15DF121UP1. This spec will be used for Air Force procurement in lieu of the basic spec MIL-C-3965 until superceded by a revision of the basic spec.

RETMA RS-182, Class A Variable Air Capacitors, March 1957

The capacitance characteristics of a class A variable air capacitor are: TRF equals 24 dielectrics: 12 stator and 13 rotor plates; and the oscillator equals 20 dielectrics: 10 stator and 11 rotor plates. This standard, from Standards Proposal 501, is a reaffirmation of REC-106-A. Copies of this standard may be obtained from Radio-Electronics-Television Manufacturers Association, 11 West 42nd Street, New York 36, N.Y. for 30 cents per copy.

Industrial Instruments

SAMA Standard RC3-12-1955, Accuracy and Sensitivity Terminology as Applied to Industrial Instruments

Published by the Scientific Apparatus Makers Association in September 1956, this standard applies to industrial instruments for plant measurements or control of temperature, pressure, flow, frequency, power, gas analysis, conductivity, pH, combustion, and similar variables. Copies of this standard may be obtained without charge from the Scientific Apparatus Makers Association, 522 Fifth Avenue, New York 36, N.Y.

Panel Cut-Out Dimensions

SAMA RC12-10-1956, Panel Cut-Out Dimensions

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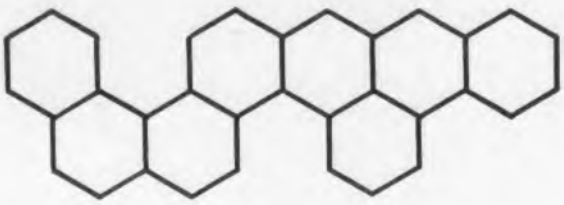

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